

LETTER OF TRANSMITTAL.

AGRICULTURAL COLLEGE, }
AMES, Iowa, February 15, 1896. }

To His Excellency, FRANCIS M. DRAKE, Governor of Iowa:

SIR—In accordance with the provisions of chapter 86, laws of the Twenty-fifth General Assembly, I have the honor to transmit herewith the proceedings of the tenth annual session of the Iowa Academy of Sciences.

With great respect, your obedient servant,

HERBERT OSBORN,

Secretary Iowa Academy of Sciences.



OFFICERS OF THE ACADEMY.

1895.

President.—H. W. NORRIS.

First Vice-President.—CHARLES R. KEYES.

Second Vice-President.—T. PROCTOR HALL.

Secretary-Treasurer.—HERBERT OSBORN.

Librarian.—H. FOSTER BAIN.

EXECUTIVE COMMITTEE.

Ex-Officio.—H. W. NORRIS, CHARLES R. KEYES, T. PROCTOR HALL, HERBERT OSBORN.

Elective.—N. E. HANSEN, W. H. NORTON, T. H. MACBRIDE.

1896.

President.—T. PROCTOR HALL.

First Vice-President.—W. S. FRANKLIN.

Second Vice-President.—T. H. MACBRIDE.

Secretary-Treasurer.—HERBERT OSBORN.

Librarian.—H. FOSTER BAIN.

EXECUTIVE COMMITTEE.

Ex-Officio.—T. PROCTOR HALL, W. S. FRANKLIN, T. H. MACBRIDE, HERBERT OSBORN.

Elective.—W. S. HENDRIXSON, M. F. AREY, W. H. NORTON.

Constitution of the Iowa Academy of Sciences.

SECTION. 1. This organization shall be known as the Iowa Academy of Sciences.

SEC. 2. The object of the Academy shall be the encouragement of scientific work in the state of Iowa.

SEC. 3. The membership of the Academy shall consist of (1), fellows who shall be elected from residents of the state of Iowa actively engaged in scientific work, of (2) associate members of the state of Iowa interested in the progress of science but not direct contributors to original research, and (3) corresponding fellows, to be elected by vote from original workers in science in other states; also, any fellow removing to another state from this may be classed as a corresponding fellow. Nomination by the council and assent of three-fourths of the fellows present at any annual meeting shall be necessary to election.

SEC. 4. An entrance fee of \$3 shall be required of each fellow, and an annual fee of \$1, due at each annual meeting after his election. Fellows in arrears for two years, and failing to respond to notification from the secretary-treasurer, shall be dropped from the academy roll.

SEC. 5. (a) The officers of the academy shall be a president, two vice-presidents and a secretary-treasurer, to be elected at the annual meeting. Their duties shall be such as ordinarily devolve upon these officers. (b) The charter members of the academy shall constitute the council, together with such other fellows as may be elected at an annual meeting of the council by it as members thereof, *provided*, that at any such election two or more negative votes shall constitute a rejection of the candidate. (c) The council shall have power to nominate fellows to elect members of the council, fix time and place of meetings, to select papers for publication in the proceedings, and have control of all meetings not provided for in general session. It may, by vote, delegate any or all these powers, except the election of members of the council, to an executive committee, consisting of the officers and of three other fellows, to be elected by the council.

SEC. 6. The academy shall hold an annual meeting in Des Moines during the week that the State Teachers' association is in session. Other meetings may be called by the council at times and places deemed advisable.

SEC. 7. All papers presented shall be the result of original investigation, but the council may arrange for public lectures or addresses on scientific subjects.

SEC. 8. The secretary-treasurer shall each year publish the proceedings of the academy in pamphlet (octavo) form, giving author's abstract of papers, and, if published elsewhere, a reference to the place and date of publication; also the full text of such papers as may be designated by the council. If published elsewhere the author shall, if practicable, publish in octavo form and deposit separates with the secretary-treasurer, to be permanently preserved for the academy.

SEC. 9. This constitution may be amended at any annual meeting by assent of a majority of the fellows voting, and a majority of the council; *provided*, notice of proposed amendment has been sent to all fellows at least one month previous to the meeting, and provided that absent fellows may deposit their votes, sealed, with the secretary-treasurer.

ARTICLES OF INCORPORATION OF THE IOWA ACADEMY OF SCIENCES.

ARTICLE I.

We, the undersigned, hereby associate ourselves with the intention to constitute a corporation to be known as the Iowa Academy of Sciences, the purpose of which is to hold periodical meetings for the presentation and discussion of scientific papers, to publish proceedings, to collect such literature, specimens, records and other property as may serve to advance the interests of the organization, and to transact all such business as may be necessary in the accomplishment of these objects.

ARTICLE II.

The membership of the corporation shall consist of the incorporators, and such other residents of the state of Iowa as may be duly elected fellows of the Academy.

ARTICLE III.

The duly elected officers of the Academy shall be the officers of the corporation.

ARTICLE IV.

The principal place of business of the Academy shall be the city of Des Moines, in the state of Iowa.

The capital stock of the corporation is none.

The par value of its shares is none.

The number of its shares is none.

ARTICLE V.

The Academy shall hold an annual meeting in the last week of December, of each year, or upon call of the executive committee, and such other meetings as may be arranged for.

ARTICLE VI.

This corporation shall have the right to acquire property, real and personal, by purchase, gift or exchange, and such property shall be held subject to the action of the majority of its fellows, or the council, the executive committee, or such parties as it may by vote direct to transact such business in accordance with the constitution.

All deeds, leases, contracts, conveyances and agreements, and all releases of mortgages, satisfactions of judgment, and other obligations, shall be signed by the president or vice-president and the secretary, and the signature of these officers shall be conclusive evidence that the execution of the instrument was by authority of the corporation.

ARTICLE VII.

The private property of the members of this corporation shall not be liable for any of its debts or obligations.

ARTICLE VIII.

By-laws, rules and regulations, not inconsistent with these articles, may be enacted by the Academy.

ARTICLE IX.

These articles may be amended at any meeting of the Academy called for the purpose by assenting vote of two-thirds of the members present.

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ALMY, F. F.	Iowa College, Grinnell
ANDREWS, L. W.	State University, Iowa City
AREY, M. F.	State Normal School, Cedar Falls
BAIN, H. F.	Geological Survey, Des Moines
BARRIS, W. H.	Griswold College, Davenport
BATES, C. O.	Coe College, Cedar Rapids
BEACH, ALICE M.	Agricultural College, Ames
BENNETT, A. A.	Agricultural College, Ames
BEYER, S. W.	Agricultural College, Ames
BISSELL, G. W.	Agricultural College, Ames
CALVIN, S.	State University, Iowa City
CHAPPEL, GEORGE M.	Signal Service, Des Moines
COMBS, ROBERT	
CONRAD, A. H.	Parsons College, Fairfield
CRATTY, R. I.	Armstrong
CURTISS, C. F.	Agricultural College, Ames
DAVIS, FLOYD	Des Moines
DREW, GILMAN	Newton
ENDE, C. L.	Burlington
FINK, B.	Upper Iowa University, Fayette
FITZPATRICK, T. J.	Lamoni
FRANKLIN, W. S.	Agricultural College, Ames
FULTZ, F. M.	Burlington
GOSSARD, H. A.	Ames
HALL, T. P.	Tabor College, Tabor
HANSEN, N. E.	Brookings, South Dakota
HAZEN, E. H.	Des Moines
HENDRIXSON, W. S.	Iowa College, Grinnell
HEILEMAN, W. H.	Ames
HOLWAY, E. W. D.	Decorah
HOUSER, G. L.	State University, Iowa City
JACKSON, J. A.	Des Moines
KELLY, H. V.	Mount Vernon
LEONARD, A. G.	Western College, Toledo
LEVERETT, FRANK	Denmark
MALLY, C. W.	Agricultural College, Ames
MARSTON, A.	Agricultural College, Ames

MACBRIDE, T. H.	State University, Iowa City
NILES, W. B.	Agricultural College, Ames
NORRIS, H. W.	Iowa College, Grinnell
NORTON, W. H.	Cornell College, Mount Vernon
NUTTING, C. C.	State University, Iowa City
OSBORN, HERBERT	Agricultural College, Ames
PAGE, A. C.	State Normal School, Cedar Falls
PAMMEL, L. H.	Agricultural College, Ames
REPPERT, F.	Muscatine
RICKER, MAURICE	Marshalltown
ROSS, L. S.	Drake University Des Moines
SAGE, J. R.	State Weather and Crop Service, Des Moines
SCHAEFFER, C. A.	State University, Iowa City
SCHLABACH, CARL	High School, Clinton
SHIMEK, B.	State University, Iowa City
STANTON, E. W.	Agricultural College, Ames
STOOKEY, STEPHEN W.	Coe College, Cedar Rapids
TILTON, J. L.	Simpson College, Indianola
VEBLEN, A. A.	State University, Iowa City
WACHSMUTH, CHARLES*	Burlington
WALKER, PERCY H.	State University, Iowa City
WEEMS, J. B.	Agricultural College, Ames
WINDLE, WILLIAM S.	Penn College, Oskaloosa
WITTER, F. M.	Muscatine
YOUTZ, L. A.	Simpson College, Indianola

ASSOCIATE MEMBERS.

BALL, E. D.	Little Rock
BARTSCH, PAUL	Burlington
BEARDSHEAR, W. M.	Agricultural College, Ames
BLAKESLEE	Des Moines
BROWN, EUGENE	Mason City
CARTER, CHARLES	Fairfield
CARVER, G. W.	Ames
GIFFORD, E. H.	Oskaloosa
MILLER, G. P.	Des Moines
MILLS, J. S.	Eugene, Oregon
OSBORN, B. F.	Rippey
OWENS, ELIZA	Ames
PAMMEL, EMMA	Ames
REED, C. D.	Ames
ROLFS, J. A.	Le Claire
SIRRIE, EMMA	Ames
WEAVER, C. B.	Ames

CORRESPONDING MEMBERS.

ARTHUR, J. C.	Lafayette, Indiana
BARBOUR, E. H.	State University, Lincoln, Nebraska
BEACH, S. A.	Geneva New York
BESSEY, C. E.	State University, Lincoln, Nebraska
BRUNER, H. L.	Irvington, Indiana

* Deceased.

CALL, R. E.....	Louisville, Kentucky
COLTON, G. H.....	Virginia City, Montana
CROZIER, A. A.....	Ann Arbor, Michigan
GILLETTE, C. P.....	Agricultural College, Ft. Collins, Colorado
HALSTED, B. D.....	New Brunswick, New Jersey
HAWORTH, ERASMUS.....	State University, Lawrence, Kansas
HITCHCOCK, A. S.....	Agricultural College, Manhattan, Kansas
JAMESON, C. D.....	
KEYES, C. R.....	State Geologist, Jefferson City, Missouri
LONSDALE, E. H.....	Missouri Geological Survey, Jefferson City, Missouri
MALLY, F. W.....	Hulen, Texas
MCGEE, W. J.....	Bureau Ethnology, Washington, D. C.
MEEK, S. E.....	State University, Fayetteville, Arkansas
NEWTON, GEO.....	Grand Island, Nebraska
PARKER, H. W.....	New York City, New York
PATRICK, G. E.....	Hopedale, Massachusetts
ROLFS, P. H.....	Lake City, Florida
SIRRINE, F. ATWOOD.....	Jamaica, New York
SPENCER, A. C.....	Johns Hopkins University, Baltimore, Maryland
STEWART, F. C.....	Jamaica, New York
TODD, J. E.....	State University, Vermillion, South Dakota
WINSLOW, ARTHUR.....	St. Louis, Missouri

PROCEEDINGS

OF THE

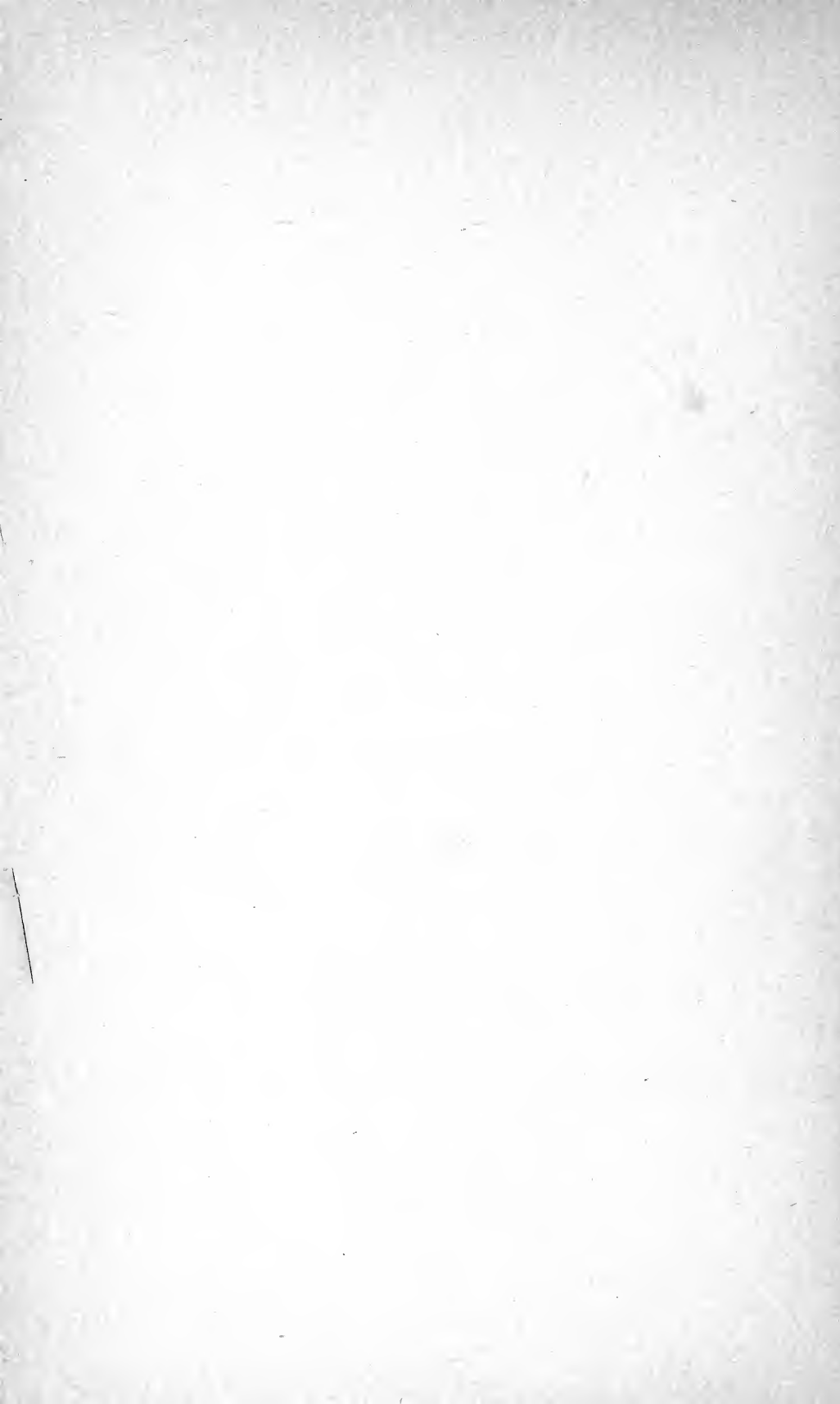
Iowa Academy of Sciences

FOR 1895.

VOLUME III.

PUBLISHED BY THE STATE.

DES MOINES:
F. R. CONAWAY, STATE PRINTER.
1896.



PROCEEDINGS OF THE TENTH ANNUAL SESSION
OF THE
IOWA ACADEMY OF SCIENCES.

The tenth annual meeting of the Iowa Academy of Sciences was held in the horticultural rooms at the capitol building in Des Moines, January 1, 2 and 3, 1896. During the business sessions the following matters of general interest were acted upon:

REPORT OF THE SECRETARY-TREASURER.

GENTLEMEN—It is a gratification at this our decennial meeting to report a flourishing condition of the academy. Comparison with our modest beginning, and with our struggles in earlier years to secure a solid foundation and to provide for the publication of results, warrants us in a feeling of satisfaction and of encouragement for renewed effort for the future.

Our membership, which now numbers over 100, includes in its list sixty-three fellows, fifteen associates and twenty-three corresponding members. It represents nearly all the active scientific workers of the state, and also many whose interest and cordial support of such work is of great value. Four of the fellows have removed from the state, and, according to our custom, may be transferred to the list of corresponding members. Four others have, at their own request, or on account of arrearages in dues, been dropped from the academy roll.

Accounts and vouchers submitted herewith show receipts amounting to \$153.21 and disbursements of \$97.22, leaving a balance charged to the treasurer of \$55.99.

SUMMARY OF RECEIPTS AND EXPENDITURES.

Receipts.

Balance from last year	\$ 63.16
Ten membership fees at \$3	30.00
Annual dues from members	58.00
Proceedings sold	2.05
Total	\$ 153.21

Disbursements.

Expenses of ninth annual meeting	\$ 6.43
Stationery and stamps, collecting dues	3.41
Printing programs, circulars, etc.	16.25
Author's reprints Vol. II	50.00
Express and postage on proceedings	19.25
Clerk hire, exchange and miscellaneous expenses	1.88
Balance	55.99
Total	\$ 153.21

Respectfully submitted.

HERBERT OSBORN.

The committee appointed to examine the accounts of the secretary-treasurer reported as follows:

The committee finds the accounts of the secretary to be correct.

Signed { C. C. NUTTING,
C. O. BATES,
A. C. PAGE.

REPORT OF THE LIBRARIAN.

DES MOINES, IOWA, December 31, 1895.

GENTLEMEN—I have the honor to submit the following report of my work as librarian of the academy for the year past. The academy is now receiving regularly forty-three serial publications, including the reports of the most important American and some of the foreign societies. In addition, the reports of a considerable number of state and government bureaus are received. The papers are catalogued and placed in the alcove assigned to the academy by the state librarian. Within the past year exchanges have been effected whereby all, or a considerable number, of the back numbers of the following series have been placed upon our shelves:

Transactions Connecticut Academy of Science.

Bulletin New Brunswick Natural History Association.

Proceedings Colorado Scientific Society.

Transactions St. Louis Academy of Science.

Tufts College Studies.

Proceedings Natural Science Association, Staten Island.

Colorado College Studies.

In two other cases exchanges were effected by the combined efforts of the Academy of Sciences and the Geological survey. In these cases it was

thought better to place the books received in the regular collections of the state library. It is proposed to continue the exchange of back sets wherever it can be done to advantage; and for this purpose, as well as to provide for exchanges already made, it is recommended that the academy purchase at least fifteen copies of part one of the proceedings.

Several copies of the back numbers of the academy have been sold and the money forwarded to the treasurer. It is recommended that some more systematic rules regarding the distribution and sale of the proceedings be adopted. Respectfully,

H. FOSTER BAIN,
Librarian.

Professor Hendrixson, for the library committee, made a statement of the work of the committee with reference to scientific books for the state library and the valuable additions that had been made as a result.

The following motion was adopted that a vote of thanks be tendered the librarian and board of trustees of the state library for their courtesies in hearing the requests of the academy and the purchases of scientific works.

A motion that a committee of three be appointed by the chair to petition the legislature regarding the preservation of forest and lake areas of Iowa and to present a memorial to congress through Senator Gear, regarding forest preservation. The committee appointed consists of Professors Macbride, Pammel and Fink. The following was adopted:

DES MOINES, Iowa, January 2, 1896.

The Iowa Academy of Sciences, in regular session assembled, begs leave to call the attention of the Twenty-sixth General Assembly of the State of Iowa to the preservation and protection of our lakes in order to maintain some of the original conditions of the state. They should be made pleasure resorts where our citizens may spend a few days for recreation, and where possible the borders of the lakes should be planted with forest trees. These lakes contain large numbers of fish which alone would pay for their maintenance. They are frequented by many birds which, without them, will be driven from our state.

Your honorable body can leave no richer legacy to future generations than the lakes that dot the northern part of our state surrounded with timber. We earnestly hope the Twenty-sixth General Assembly will pass some measure to preserve them.

(Signed)

T. H. MACBRIDE.
L. H. PAMMEL.
B. FINK.

DES MOINES, Iowa, January 2, 1896.

The Iowa Academy of Sciences, in regular session assembled, begs leave to call the attention of the United States congress to the absolute necessity of further legislation looking to the preservation and rational use of the remaining forest resources of our country. The academy petitions for

larger and better guarded reservations, for the enactment of the McRae bill, H. R. 119, or of some similar measure which will yet more stringently guard our forests.

(Signed)

T. H. MACBRIDE.

L. H. PAMMEL.

B. FINK.

The following resolution was adopted:

Resolved, By the Iowa Academy of Sciences, that we view with pleasure the efforts toward providing a state building for the preservation of material of historical and scientific value and would heartily endorse the movement for a "memorial, historical and art building."

The following resolutions in regard to papers were adopted:

That hereafter no papers will be published in the proceedings of this academy which are not placed in the hands of the secretary in full, or in a written abstract, before the adjournment of the annual meeting.

That no paper shall be placed upon the printed program of the academy unless the title, when handed to the secretary, be accompanied by a brief abstract and that these abstracts be printed with the program.

The thanks of the academy to the State Horticultural society for the use of their room were by motion tendered.

In the sessions for the reading and discussion of papers the academy listened to the annual address of the president and papers giving results of investigations.

These papers read in full or by title were referred by the council to the secretary for publication and follow herewith:

ANNUAL ADDRESS OF THE PRESIDENT.

NEEDED CHANGES IN SCIENTIFIC METHODS.*

BY H. W. NORRIS.

We live in a period that sees wonderful attainments in science and art, so that in theory and practice many think the *summum bonum* has been reached. It is pre-eminently the age of science and the application of scientific methods to all phases of human activity. The forces of nature have been made subject to the will of man. The relations of man to his surroundings have been carefully considered. The province of human intellect has been made the ground of scientific investigations. We now see scientific methods foremost and uppermost, and all human thought is more or less permeated and even molded by the new ways of looking at the facts of our experience and reason. But with all our enlightenment no other age has equaled ours in the prevalence of unblushing fraud and boasting duplicity.

For every skilled specialist in surgery we have a dozen quacks, whose outrageous pretensions are only equaled by the astonishingly large patronage of the over-credulous. The reputable physician struggles along in his attempts to right the wrongs of the human body according to the best approved methods, and too frequently receives as his reward only non-bankable promises, while Dr. Humbug puts up at the best hotels, advertises to cure all the ills human flesh is heir to, and reaps a harvest of shekels. The name of Dr. X's sarsaparilla is emblazoned along every thoroughfare in the country, and the

* When this address was nearly completed a copy of a recent lecture by President J. M. Coulter, of Lake Forest University, was received, in which were expressed many ideas quite similar to some contained in this paper. Wherein the writer has intentionally borrowed from President Coulter, due credit has been given.

The Botanical Outlook. An address delivered before the Botanical Seminary of the University of Nebraska, May 27, 1885.

merits of the Whoop-up Indian Bitters have even been dramatized for the stage. But the "regular" physician is held responsible for the final taking off of the poor dupes who have resorted to all the patent medicines before consulting the proper authorities. The discoveries of Edison and other investigators of nature's forces are quietly revolutionizing our industrial methods, and we think little of it. But the praises of electric belts, electric bitters and magnetic oils are sounded in every hamlet where the public press finds expression. We have seen in this generation the revival of an old imposture, that travesty on religion and science, the so-called Christian science. Occasionally a new messiah makes his appearance, drawing after him such throngs as to make the possibility of another Joseph Smith not an incredible idea. A visit to one of our interstate or international exhibitions fills us with wonder amounting almost to awe at the marvelous products of genius, a wonder exceeded only by that aroused by a perusal of the advertising columns of our daily papers. That advertising pays cannot be disputed, but the fact that it does pay is often a serious reflection upon the methods of our mental training. Fence corners full of abandoned machinery show, among other things, an unfortunate ignorance of physical laws, and a too-ready acceptance of golden promises. In spite of our bureaus of animal industry, the stock raiser still resorts to patent condition powders and hog cholera cures instead of managing his establishment on a sanitary basis. We are too much under the impression that everything—life, health and happiness, can be purchased with the almighty dollar. So we throw discretion to the wind and leave the results to the Lord and the doctors.

To-day, as it has always been, empiricism is a great hindrance to progress. A specific remedy for a specific evil, a lucky discovery of certain correlated phenomena, a haphazard experimenting with fortunate results, have been all too frequently characteristic of scientific achievements. Great as are the victories science has won in the domains of medicine and the applied arts, they have not been presented to the great public as having a rational basis. In fact the leaders in science see only too dimly the underlying meaning. To many the sole purpose of research is to turn up to view new facts. Facts are presented as interesting, or as having a practical bearing, or as having no bearing at all. The prosaic, dull drudgery of tracing relationship is omitted. Yet nothing exists out of relationship.

In the inductive sciences that deal with facts of most obvious bearings we are magnifying the importance of isolated details and largely ignoring the idea of relationship. As long as people fail to understand that nothing is superior to law, so long may we expect the search for perpetual motion, the elixir of life and the fabled pot of gold. Metaphysicians tell us that the idea of cause is intuitive, yet vast numbers of people act as though cause and effect had no relations whatever in some realms of human experience. The extraordinary success attained by many investigators and inventors has produced a widespread notion that these successful ones are creators rather than discoverers, and that their genius (so-called) transcends common laws. The spirit of speculation so rife in society at present seems to subsist largely on the idea that the common laws of experience are often inoperative. Can we wonder at the enormous sales of patent nostrums as long as there is a widespread opinion that medical science has no rational basis? Can we wonder at the successful impositions of faith-healers and medicine-men when each holder of a physician's diploma is considered a law unto himself, entitled to experiment at his own sweet will on suffering humanity? Is it strange that people fail to be guided by reason when the materials of experience are like so much wind-blown chaff? Says the worldly-wise man of to-day: "My son, be a freak, an honest freak if convenient, but by all means be a freak, for in freak-ism is success."

I therefore make no apology for presuming to make a plea for scientific thought. We may indeed be proud of our achievements in science. In this, the latter part of the nineteenth century, the age of Edison, Pasteur and a host of other investigators, we need make no defense of the position science occupies in human thought and action. The air ship, the electric engine, the dynamite gun, are but faint indications of what is yet to be accomplished. The triumphs of surgical skill are just begun. We see the forces of nature arrayed against each other to give a purer atmosphere, a richer soil, a freer life to mankind. Material considerations outweigh all others in the arena of public opinion. Some say the world has gone mad with science. Scientific studies have crowded themselves into the public schools, colleges and universities in spite of the opposition of the classics. The children lisp in scientific phrases, and the old men sigh for the good old times when ignorance was bliss.

I am neither a prophet nor the son of a prophet, nor am I related by blood or marriage to any prophet or son of a prophet. This age may be as badly in need of prophets as any other age, but what it needs most of all is common sense methods of dealing with the problems that confront it. It seems to me we may profitably spend a little time in the consideration of some of the bearings of scientific methods on current thought and action.

What is the *scientific spirit*? Some would say it is the spirit of the age. But it may well be doubted whether there is such a thing as a spirit of the age. With people and their wants so diverse, the general instability of changing institutions make a universal animating spirit well nigh impossible. But the scientific spirit is something definite and characteristic. We may notice some of the things it is not. It is not the mere seeking for truth, for many who seek the truth are content with half truths. It is not enthusiasm, for the enthusiast too often stands in his own light. It is not the mere collecting of data, for facts and the records of facts in themselves are well nigh worthless. The scientific spirit seeks to demonstrate no proposition; it is not partisan. In short, the man imbued with the scientific spirit seeks the whole truth in all its relations, and accepts its teachings regardless of consequences.

We need to scrutinize very carefully a large amount of the so-called science and scientific methods of to day. The word scientist, has become a sort of abrakadabra, by means of which men hope to conjure up the objects of their hopes and desires. Science is too often interpreted as the triumph of shrewdness over simplicity, the hoodwinking of the ignorant and innocent by the ingenious sharper, or the successful defeat of an opponent through chicanery. So far is this carried sometimes that we are ready to paraphrase that famous expression of Madame Roland and exclaim, "O, science what crimes have been committed in thy name." Any addition to our knowledge that does not affect and improve all classes only lowers relatively the under strata of society; any advance in science which does not adapt itself to the masses only renders them more helpless in the hands of the unprincipled but more intelligent. Science and scientific methods are not for the few, but for the many. We must not assume that scientific methods have no place in common affairs. The scientific spirit is not a new but an old factor in human progress. But we are too much inclined to relegate science and scientific procedures to the specialist, the *scientist*, and as the

specialist and the quack are not distinguishable by the masses the results are often lamentable.

It is said that the cranks and irrational enthusiasts initiate all reform, not the sober, scientific minds; that the scientific mind is conservative and never leads a reform. If this were true, nevertheless it is always the sober, common-sense ideas that really accomplish the final good. Reformers are too often impracticable men. It requires all the best scientific methods combined with the best judgment to achieve the final results and eradicate the evils that follow in the wake of every reformer. We need not so much reformers, for there are plenty of them, but rather the application of scientific methods to the solving of human problems.

The charge is often made that the theoretical sciences are not practical; that they have no direct bearing on the pursuit of health, wealth, and happiness; that they yield no results of value adequate to the time and labor spent on them. Not long ago a bright young scientist lamented to me the fact that his chosen line of work, systematic botany, was so useless, and that biologists in general contributed nothing to the welfare of the human race. It is said that Louis Agassiz made the profession of naturalist respectable in America. Before his time it had been barely tolerated. While scientists of to-day are considered equally worthy with other citizens, yet if their labors do not directly materialize in glittering gold they are everywhere confronted with the question, "Of what good is it?" And, owing to the peculiarities of the questioner, very frequently no satisfactory answer can be given. But an answer is needed.

The teaching of that only which is directly practical tends to swamp all progressive ideas. To restrict our energies to the already known is to degenerate. The cry, "Give us practical studies" is a note of warning. It means stagnating tendencies. To concentrate our energies on practical details too often means to ignore broader relations. We see a wonderful development of technical schools and appliances for the study of the applied arts. To many this seems the scientific goal. Many believe that all our energies should be directed to the promoting of the applied sciences, and that the day of theoretical science is past. So we hear demands for manual training departments of our public schools; demands that the literary and general culture of school life shall be minimized for the enlargement of the practical sciences. We see the young being

hurried into the trades and specialists sent out who know nothing but their little tread-mill round of practice. Is it true that botany, zoology, astronomy, and theoretical chemistry and physics have no great value, and that aside from their purely disciplinary effects they might as well be consigned to the rubbish heap? By many the field of the natural sciences is regarded as a playground where the mind may relax itself in intellectual somersaults.

I would not be understood as antagonizing technical schools, or as depreciating the value of a technical education, but I do say that a general demand for the practical shows something wrong in our educational system. Either we are failing to render the general culture effect of our teaching of much value or we are holding out false notions as to the practical value of our studies. I believe the former to be the true cause. We are not seeking to discipline the mind in proper channels so much as to fill up the cup of mental capacity with scholastic hodge-podge. The great fault of science in our educational scheme is not that it is not practical, but that too often it is not much of anything. We are loading our courses of study with a great bulk of interesting things, "such as every one ought to know something about." Look at the program of studies of the average high school: a term each of botany, zoology, geology, astronomy, physiology, physics, chemistry, etc. What knowledge does the student gain of the inductive methods of study? Occasionally a little, usually none. What practical ideas does he acquire? Some, no doubt, yet in the text-books ordinarily used error is about as conspicuous as truth. If we could confine our science teaching in the public schools to a year of physics and an equal amount of some other one science, and concentrate our energies on quality instead of quantity, method instead of matter, the good results would be ten-fold what they are at present. I am confident that in proportion to the time spent upon it our science teaching yields fewer results than any other line of public school work. The same criticism may be applied to many of our higher institutions of learning. It is no wonder the public calls for something practical.

When the inductive sciences were given such a conspicuous position in our educational system as they occupy to-day, it was thought society was in a fair way to free itself from many errors. But we have too often gone merely from an error to a blunder. Our college and university training has too often

concentrated itself on less important details and ignored broader principles. While it can not be said of many of our colleges, as was recently said of a leading American university, that its zoological department had all run to scales and tail feathers, yet it is true that we are burying relationships under a bewildering mass of details. It must be confessed that some of our latest and most improved methods, notably of those biological studies included under the term morphology, have a tendency to increase rather than diminish this evil. There is always the danger of mistaking the means for the end. The fault of science teaching in our public schools lies in the fact that the student gains little or no conception of the bearing of scientific study on his life. The facts of science are presented as so many isolated entities, interesting or uninteresting as the case may be. The high school must not be looked at and judged as a preparatory school for college training, but as a finishing school for a large part of our school population. The studies should be arranged not as leading to a college curriculum, but as preparing pupils for active life, not by loading their brains with facts, but by training their mental activities. In this latter respect high school science makes a lamentable failure.

I make no tirade against public schools. The fault lies largely and chiefly with the schools that prepare our teachers for science teaching, *i. e.*, our colleges and universities. We may say the public schools are behind the times in this respect, and they are merely following the lead of publishers of antiquated text-books. This may be true, but nevertheless the evils of science teaching in our high schools are only miniatures of those that exist so frequently in our colleges.

What do I consider the pre eminent good to be obtained from the study of the inductive sciences? To enable the mind to detect the living truths; to perceive that every effect may be referred to an appropriate cause; to see that nothing is independent of relationships; to see that human activities are intimately bound up with other activities; and that the individual is but part of a whole. In other words, to adjust the mind to the sum total of its environment. When we can once establish our scientific training on such a basis, empiricism, charlatanism, and all the frauds that prey on human credulity must beat a retreat.

Fellow laborers, we are not doing our duty. We are too often content with quantity instead of quality. We cover too much ground and look for premature results. We fail to keep in mind the great idea, that method is more than matter, that the result we seek is not accumulation but power, not acquisition but capacity, not bulk but strength. And we also forget that every scientist is a teacher, whether officially so or not. I believe that science and scientific study have a direct bearing on human existence. I believe that the sciences are not merely interesting, disciplinary as studies, practical when applied in the industrial arts, but that the more scientific people are the happier they are, not that they are warmer, or less hungry, or more intellectual, but that they are better adapted to their surroundings. In other words life ought to mean more than struggle, acquisition and success, it should mean better relationships. I do not believe that the chief end of scientific training is skill in invention. I do not think the chief business of the scientist is to produce something practical. This age is pre-eminently practical, and in so far as it is so it depends largely on scientific methods in vogue. But the satisfaction of bodily wants and natural ambitions is not the goal of scientific research. We need not less but more theory with our practice. The man without a theory is as unbalanced as one with nothing but a theory. The aim of scientific research is to find the ideal adjustment of man to his environment, and that relation will never be attained by purely practical means.

We see to-day an immense number of so-called investigators engaged in original research. Probably one-half of these know little or nothing beyond their specialties. Many of them are engaged in matters of little general import, and see only a very circumscribed horizon. Many of them are unable to see the relations of their special studies to anything else. So they drift into empiricism, narrowness, and dogmatic assertions. We are teaching men to specialize before they can generalize, and the results must be unfortunate. A large part of these investigators are entirely out of place. To become a specialist in science one must be more than merely able to manipulate a microscope, or to set up a dynamo, or to mix chemicals without a disastrous explosion. Whatever may be said pro and con regarding the old system of industrial apprenticeship, this is certain, that no one can become a reliable investigator without a long and laborious service of preparation. We are putting

the label, investigator, upon too much crude material. To quote President Coulter: "Teachers assume a serious responsibility in urging born hod carriers to become architects."

I do not wish to be understood as decrying original research or specialization of studies. On the contrary, I believe every earnest thinker needs to concentrate his energies now and then on special investigation, but every act in specialization should rest on a foundation of broad culture. No scientist should be content to pass off the field of activity without leaving the store of human knowledge richer for his having lived. If we consult the life records of those who have done most to put the various branches of science on a broad rational basis, we see that they have been men who have got at the heart of nature through special investigations. Only those who have labored themselves can rightly interpret the labors of others. Knowledge is not the goal. Truth for truth's sake may be good, but not best. Unrelated ideas are as valueless as mummies buried beyond all discovery. We are making an egregious mistake when in our teaching or researches we emphasize a detail here and a detail there and utterly fail to find any relationships. Yet this is just what is done over and over again by our so-called investigators. Year after year they extol their special hobbies and lament that the world calls them visionary.

I believe in the popularization of science. It would be entirely out of place for me to assume that any member of this academy believed in what is known as popular science, which in fact is usually no science at all. I believe that science should be made popular, not by prostituting its aims and methods to the pleasing of public fancy, but by educating the masses in the methods and applications of science. Correct thinking is prerequisite to correct acting. Yet how often do we labor simply to reform the acting! Comparatively speaking, of what lasting good can be the triumphs of science of our day if only the purely practical results impress themselves on the public mind? If our discoveries, little and big, are to be applied as so many patent nostrums how meager the results! If the *rationale* of science is to be restricted to the sphere of the highly educated classes and the wonderful results of research are to be regarded as empirical by the masses, how discouraging the prospect to one who has at heart the welfare of the whole race! Pasteur and others have well nigh succeeded in placing medical science on a rational basis, yet how few comprehend the actual state of

matters! How many physicians themselves look upon their profession as founded on empirical data! The failure of the public to recognize fundamental principles accounts largely for the success of many of the frauds of our day. We look upon professional and technical schools as places where the student gains skill in manipulating and proficiency in experimenting, and too often that is all they are. The scientist is often justly accused of isolating himself and his work from the sphere of human activity, of seeking his little bit of truth merely for the truth's sake, never dreaming that his greater duty is to relate himself and his work to the great body of truth. No one has a natural monopoly on truth any more than on any other reality. I do not believe in a scientific Olympus where above the clouds and turmoil of the common place, far from the maddening crowd, can dwell the votaries of science indifferent to the problems that perplex the masses. If the true aim of scientific study is to find the ideal adjustment of man to his environment our present progress in realizing that aim is altogether too slow and uncertain in comparison with our pretensions. We must make radical changes in the ways we are presenting the facts and methods of science to the public.

The observing minds of to-day cannot fail to see that modern civilization is on the point of some great changes. The first half of the twentieth century will see enacted what would now seem subversive of the present best order of things. The wisdom and folly, success and disaster, attending these changes will depend largely on the scientific or unscientific means employed in attaining desired ends. It is basest folly to attempt to solve society's problems with leaving out of sight fundamental human laws. There is no true science of sociology yet formulated. The dictum of the social reformer is the baldest empiricism. We can never get anywhere by Bellamy colonies and Brook Farm experiments. Why then advocate social schemes to which not even the angels in heaven could conform much less men of flesh and blood? If sociology is ever to be established on a rational basis it must take man as he is, and as he has been, a creature of bone and sinew, ever striving for better conditions and never presenting phenomena that are independent of natural laws. Sociology can be made a science only by laborious patient endeavor. Humanity's problems cannot be solved in a day, nor a year, nor a lifetime. No one man can solve them. The chemist, the biologist, the

physicist, the ethnologist, the mechanic, must assist. What a pathetic spectacle is presented in the charitable and mission work man is doing for his fellow man. It is the old story of eradicating one evil and sowing the seeds of a dozen more. How little of philanthropic work aims at more than alleviating present conditions! Were it not for the fact that in some instances, and they are all too few, the highest of scientific attainments are being directed toward studying and correlating the fundamental laws of society for the purpose of establishing abiding criteria of action I should deem the field of social reform utterly hopeless. We evidently need not so much a change of method here as a change from no method at all to a scientific method.

The scientific world stands committed to the theory of evolution, for by no other can the existing order of things be explained, even though much is as yet unexplained. It is the only thing that can bind our scientific knowledge into a cohering whole. Any ignoring of it plunges into deepest empiricism. The ideas of growth, development, change from simple to complex, and resulting inter-relationships are extremely vague in popular thought. Particular modes of procedure are often mistaken for general principles, this or that theory for a law. One of the greatest obstacles that the theory of evolution, the only real interpreter of facts, has had to contend with has been and is now the widespread belief in infallibility—infallibility of all knowledge. Yet no more important truth needs to be learned than that the wisdom of to-day may become the folly of to-morrow. A change in belief is too often mistaken for an exchange of an old for a new dogma. The fact that scientific theories and knowledge in the year 1893 are not like those in the year 1859 constrains many, particularly those of a theological bias, to deny any truth in either. Nor do many scientists place themselves in any more commendable attitude. Some of our scientists give evidence of as intolerant a dogmatism as ever disgraced ecclesiastical history. The man who assumes infallibility of scientific knowledge, in whole or in part, thereby puts himself beyond the pale of truth seeking.

President Coulter notices among botanists of to-day several bad tendencies. Some of them have so wide an application that I may use them in recapitulating my preceding statements:

1. *The tendency to narrowness.* This is shown in the magnification of details, and minimizing of relationships; in the failure

to recognize the applications of science in whole or in part. 2. *The tendency to certainty*—dogmatism, infallibility. This reaches its culmination in the balancing of a scientific chip on the shoulder. 3. *The tendency to mistake acquisition for the power to do something*. This is profoundly characteristic of science teaching in our educational system. 4. *The tendency to immature research*—dilettantism. To which I would add: 5. The tendency to Phariseeism; the scorning of all not scientists; a holier-than-thou attitude that puts the possessor out of touch with human struggle; the despising of all efforts that are not of a certain superfine order; lack of charity for fellow scientists; criticism of every man's honest endeavor. 6. The tendency to minimize theoretical considerations; the cry for the practical.

It is obvious that these tendencies cannot fail to create a feeling in popular thought of distrust, contempt, and disregard of science and scientific methods. The effect on the scientist is stultifying, narrowing, dogmatizing. The worst result will be that progress in solving humanity's problems will be retarded. Every tendency to restrict the application of scientific methods is detrimental to progress.

I believe that science and the methods of science must take in the future a greater share in shaping the destiny of the race than they have in the past, not so conspicuous perhaps, but none the less real. I believe most profoundly in an earthly order founded on a scientific basis. I see no other hope for society. I am not visionary. Hence I can make no forecast of a rainbow-tinted land of promise, wherein the plutocratic lion deals with the democratic lamb on a strictly scientific basis. Scientific method is not a universal panacea. But the problems that perplex humanity will be settled justly only as they are approached from a rational standpoint,

I am not pessimistic as to the future of science. But the best results will not be achieved unless some of our methods are radically changed. Materialism and philosophic nihilism are no bugbears to me. Though science and scientific methods cannot make a perfect humanity, any attempt to solve the problem by ignoring science is basest folly. I believe the day will come when empiricism and its twin brother dogmatism will yield the field to the scientific spirit. Speed the day!

HOMOLOGIES OF THE CYCLOSTOME EAR.

BY H. W. NORRIS.

The ear of the Cyclostomata has until recently been considered so peculiar as to render it difficult to explain its relations to the typical Vertebrate ear. Then again, the diversity of structure in the auditory organ of the Cyclostomes themselves renders the task of homologizing the various parts somewhat uninviting.

Our exact knowledge of the structure and relations of the ear of the Cyclostomata begins with the researches of Ketel¹, in 1872. His predecessors had assumed that the auditory organ of the Cyclostomata was a thing *sui generis*, hence most of their observations were defective. Ketel was the first to attempt to find a fundamental type of the vertebrate ear. While the results of his studies in that direction did not find ready acceptance, nevertheless, in the light of most recent investigations, we see that his conclusions were essentially correct. In the light of zoölogical knowledge twenty years later, his opinions would have seemed not only reasonable, but they would have been considerably modified from their original form. Johannes Müller² in 1836 discovered the semicircular canals in the ear of Petromyzon, and that they were only two in number. Dumeril³ in 1800 claimed to have found the canals, but his statements are extremely vague. Other observers, Pohl⁴, Weber⁵, Blainville⁶, Rathke⁷ and Breschet⁸, had denied the existence of the

¹ Ueber das Gehorogan der Cyclostomen.—Hasse *Anat. Studien*, 1872.

² Ueber den eigenthümlichen Bau des Gehororgans bei den Cyclostomen. *Fortsetz d Vergl. Anat. d. Myxinoiden in Abh d. K. Akad. d Wissen.* Berlin, 1836.

³ Anatomie des Lamproies *Mémoires d anatomie comparee.* Paris, 1800.

⁴ Expositio generalis anatomica organi auditus per classes animalium. Vindobonae, 1818.

⁵ De aure et auditu hominis et animalium. Leipzig, 1820.

⁶ De l'organisation des animaux ou Principes d'anatomie comparee. Paris, 1822.

⁷ Bemerkungen über den inneren Bau der Pricke. Danzig, 1826.

⁸ Recherches anatomiques et physiologiques sur l'organe de l'ouïe des poissons. *Acad. des Sci Savans Etrangers.* 1838.

canals, or at least any more than as rudiments. It was very early recognized that two distinct forms of ear were to be found in the group of Cyclostomata, the one found in the Myxine and the other in the Lampreys. Müller⁹ first gave any adequate description of the ear of Myxine. Previously Anders Retzius¹⁰ had given a very meager description. Ketel attempted to show that the ear of Myxine is genetically related to that of higher vertebrates through the ear of Petromyzon as a connecting link. Unfortunately he failed to recognize the existence of semicircular canals in the ear of Myxine, considering the membranous vestibule as merely a ring. Ibsen¹¹ had in 1846 recognized a semicircular canal in Myxine and two ampullae.

Ketel considered the Cyclostome ear as in an arrested stage of evolution, and that it really represented an ancestral condition of the Vertebrate ear. He sought for traces of the third or horizontal canal in Petromyzon, and believed he found it in a sense organ connected with the *crista acustica* of the anterior canal. The cochlea he found represented in the "sackartiger Anhang" of the membranous labyrinth. Ketel failed to completely homologize the Cyclostome ear with that of the Vertebrate type, because he did not recognize the existence of semicircular canals in Myxine, and further, because, working from the higher types downward, he had not grasped the idea of the fundamental form of the auditory organ. Gustav Retzius¹² in 1881 recognized the existence of a single semicircular canal in Myxine; but he did not agree with Ketel as to the relationships of the ear of the Cyclostomata. It remained for Ayers¹³ in 1892 to establish beyond question the rank of the Cyclostome ear. Starting with the idea that the Vertebrate auditory organ is composed of modified sense-organs of the lateral line system, he shows almost beyond question that the Cyclostome ear is not a degenerate structure, but rather represents an ancestral type. According to this interpretation, we recognize in the Vertebrate ear two originally distinct parts, an anterior utriculus and a posterior sacculus, with which, and forming a part of, are a number of canals. The ear of Myxine

⁹ Loc. cit.

¹⁰ Ytterligare Bidrag till anatomien af Myxine glutinosa. *Kongl. Vet.-Akad. Handl.* Stockholm, 1824.

¹¹ Anatomiske Undersogelser over Orets Labyrinth, afsluttet af Forgatteren i 1846.

¹² Das Gehororgan der Wirbelthiere I, Stockholm, 1881.

¹³ Vertebrate Cephalogenesis, II. A Contribution to the Morphology of the Vertebrate Ear, with a Reconsideration of its Functions. *Journal of Morphology*, Vol. VI, Nos. 1 and 2. 1892.

is seen to consist of a utriculo-sacculus, imperfectly divided into two parts, into which open two canals, each with an ampulla containing a sense organ. Unlike the condition in the Lampreys, or higher Vertebrates, the two canals unite with each other without an unpaired connection, or commissure, with the vestibule. Hence the failure heretofore to recognize more than one canal. The ear of *Petromyzon* differs from that of *Myxine* chiefly in the fact that the two canals are connected with the membranous labyrinth at their point of union by an unpaired commissure. The two semicircular canals of the Cyclostome ear correspond to the anterior and posterior canals of higher Vertebrates.

The anterior is connected with the utriculus, and the posterior with the sacculus, at their ampullar ends. In other vertebrates the connection of the posterior canal with the sacculus is lost at an early stage of development, so that the three canals in the adult are connected only with the utriculus. This, however, is not the ancestral nor the early embryonic condition. Embryology¹⁴ indicates that the vertebrate ear early consists of two parts, an anterior utricular and a posterior saccular region. This is the adult condition in the cyclostomes. Ayers calls particular attention to the fact, which Ketel, Hasse, and Retzius had already noticed, that in *Petromyzon* there are two distinct endolymphatic ducts, a further striking indication that the vertebrate ear is a two-fold structure in origin. Ayers, however, gave the first explanation of their presence. That the existence of these two ducts is a fundamental characteristic, is indicated by the fact that they are distinct from a very early stage of development.

Unfortunately the material at my disposal does not give a complete series of the development of the ear, but the stages studied by me indicate that Ayers is correct in his interpretation of their presence. Thus we see that recent investigation confirms the opinion of Ketel that the auditory organ of the Cyclostomata is not an aberrant structure. Ayers may be said to be the first and only one who has given a coherent explanation of the structure and origin of the Vertebrate ear.

¹⁴I. W. Norris. Studies on the ear of *Amblystoma*. Part I. *Journal of Morphology*, 1892.

ORIGIN AND SIGNIFICANCE OF SEX.

BY C. C. NUTTING.

This paper is not presented as a contribution to our knowledge of the subject of the origin of sex, so much as an attempt to express concisely a theory of sex drawn from various sources, but principally from a work on the "Evolution of Sex" by Geddes & Thomson, a work which seems to me to mark an epoch in the science of philosophical biology.

My excuse for presenting this subject before you to-night lies in the fact that it has been my fortune within the past year to personally investigate the origin of the sex-elements in one group of animals, the hydroids, and to follow in the footsteps of that great master August Weismann, whose studies have given such an impetus to the search for truth in the realm of sex and heredity.

My own studies have resulted in a conviction that there is truth in the theory advanced by Geddes & Thomson, and my effort this evening will be to state this theory, in a slightly modified form, in a series of definite propositions, each one of which I believe to be defensible, if not invulnerable.

First, however, it will be necessary to call to your minds the most important facts concerning reproduction among the one-celled animals, or *Protozoa*.

The simplest form of reproduction is that of the amoeba, in which there is a simple division of the body mass of the parent cell into two portions, each of which becomes an independent organism. This is known as the process of reproduction by fission.

Turning to a somewhat higher group of *Protozoa* we find another step introduced in the reproductive process. If we study the *Paramecium*, for instance, we will find that it multiplies by fission, as does the amoeba, but that at intervals

another process takes place, two individuals becoming adherent, the cell walls in the region of contact being dissolved as punctured, and an interchange of the protoplasm taking place. After this the individuals separate and the process of fission is renewed, and goes on for many generations. Ultimately, however, the process of conjugation is again resorted to.

In certain of the *Vorticellidae* the reproductive process is still further complicated by the fact that the fission is not simple but multiple, one of the halves resulting from simple fission again dividing into a number of small ciliated bodies, each of which is capable of uniting with a normal vorticella in the process of conjugation.

In certain Acinetans the multiple fission is internal, the parent cell having its contents broken up into a number of ciliated bodies, which escape through the ectosarc.

We thus see that in going from the lower to the higher Protozoa we find the reproductive process growing more and more complicated. First in the amoeba we find simple fission, then in the Paramecium we find simple fission plus conjugation. In the vorticella we have simple fission plus multiple fission plus conjugation. In the acinetan we find simple fission plus internal multiple fission plus conjugation.

Such, then, are the facts. We now turn to seek an explanation.

Anabolism is the constructive, conservative, potential energy of the cell.

Katabolism is expressed in the destructive expenditure of this energy in active or kinetic processes.

The growth of any normal cell has a necessary limit due to a purely physical cause. The mass increases as the cube of the diameter, while the surface increases only as the square. The surface performs the function of respiration, but it cannot perform this function for an unlimited mass any more than a cubic inch of lung can perform respiration for a full grown man.

As a cell increases in size its mass increases more rapidly than its surface, until a point is reached beyond which it can not grow, because the surface can supply no more oxygen. It is worked to its limit, and can not respond to increased demands. At this stage there are three possibilities:

First.—Death, which would end the question.

Second.—Stationary balance, which is impossible.

Third.—Katabolism, which would cause the cell to disappear, or anabolism would recur at a certain point, and we would thus have an alternation or rhythm of katabolic and anabolic states.

This is logically conceivable, but it would debar the possibility of reproduction, and the individual cell would be theoretically immortal, but as a matter of fact would be destroyed ultimately by accidental means.

If, when the cell had reached the limit of size, it should divide, either accidentally or otherwise, there would result two individuals, both small enough to admit of an expression of anabolism in growth.

There would thus be two organisms to hold the fact of specific existence instead of one.

Therefore, any cell which would divide would have double the chance of perpetuation that a single cell would.

In other words, cells capable of spontaneous or mechanical fission would be selected and preserved by natural selection.

Let 1,000 generations proceed thus by simple division or fission. By this time considerable differences would exhibit themselves in the descendants of our original cell, owing to differences in environment and food supply.

One line of cells would be abundantly fed, would grow *large, inactive, anabolic*. Another line would be insufficiently nourished, and would grow smaller, more active, *katabolic*.

Taking the large anabolic cells, we find:

First.—They tend to become more and more inactive. (Activity may express itself either in motion or cell division.)

Second.—The anabolic cells accordingly tend to become quiescent on the one hand, and to cease dividing on the other.

Third.—This tendency would ultimately result in death, if not in some way counteracted.

Taking the smaller katabolic cells, we find:

First.—They tend to decrease in size.

Second.—They tend to become more and more active.

Third.—Their expenditures would eventually bankrupt them, they would be worn out, would die of exhaustion.

Taking the two kinds of cells we find:

First.—One needs something that can express itself in cell division, *Katabolism*.

Second.—The other needs nourishment which would express itself in growth, *Anabolism*.

In other words:

One is full and dying of plethora.

The other is hungry and dying of excessive expenditure of energy.

It would evidently be a good thing for them to pool their issues.

This is effected by the process of conjugation, whereby:

First.—The small, active, katabolic cell imparts its energy (kinetic) to the large passive cell, and that energy expresses itself in *cell division*.

Second.—The large, passive, anabolic cell imparts to the daughter cells its anabolic propensities which express themselves in *growth*.

In other words:

The anabolic cell receives the impetus necessary to cell division or fission, and the katabolic cell receives nourishment and the tendency to grow.

What brings them together?

Hunger, or its equivalent.

Hunger is a fundamental property of all things that need nourishment.

It is therefore a property of katabolic cells. The small, active cells need nourishment. The large, anabolic cells are packed full of nourishment.

Example—Acinetan.

An intensification of this process would be brought about in time by natural selection and would result in *multiple fission*, external and internal, which is the highest expression of sex found among the Protozoa.

SEX IN THE METAZOA.

Hydroid as a Type.—The male cells originate from amoeboid endodermal cells which differentiate along the line of katabolism. They divide repeatedly and eventually become the smallest and most active cells in the colony. The female cells originate from amoeboid endodermal cells which differentiate along the line of anabolism. They grow excessively and become passive and circular in outline. They eventually become the largest and least active cells in the body.

These two cells unite, or the smaller seeks the larger and is absorbed in it. As a result:

First.—The small, active cell imparts its kinetic energy to the large, passive cell, and that energy expresses itself in cell division.

Second.—The large, passive, anabolic cell imparts to the daughter cells its anabolic propensities, which express themselves in growth.

By the growth and division of cells every organism, from the hydroid to man himself, attains its perfection.

It will be seen from what has been said that there is no fundamental difference between the reproductive processes in the Protozoa and Metazoa. All of the complicated machinery associated with sex in the higher forms are merely accessory to the fundamental fact of the meeting of two cells, an intermingling of protoplasm and a subsequent cell division, all of which phenomena are essentially present in the conjugation and fusion of the *Paramecium* for instance.

As to the *significance of sex*, it is not sufficient to say that it serves to perpetuate the species. It does much more. It serves to *improve* species in that the commingling of the characteristics of two parents furnishes the main potentiality for individual variation among the offspring. Indeed, Weismann stoutly maintains that we have here the only cause for individual variation upon which natural selection can act, and he believes that evolution would be impossible among sexless animals. However this may be, it is clearly true that progress is much more rapid and certain by virtue of the fact that most individuals animals have a *father and a mother*.

It would be impossible in the limits of this paper to discuss the tremendous ethical, social and moral significance of sex. It must suffice to suggest that altruism had its birth in the world when brutes first cared for and protected their helpless young, and that through the social relations of parent and child, husband and wife, all that is purest and best in human affairs found its inception and its impetus.

THE REDUCTION OF SULPHURIC ACID BY COPPER AS A FUNCTION OF THE TEMPERATURE.

LAUNCELOT W. ANDREWS.

The object of the experiments described in this paper was to determine whether the reduction of sulphuric to sulphurous acid by copper takes place at a lower or at a higher temperature than the incipient dissociation of the former compound into water and the acid anhydride.

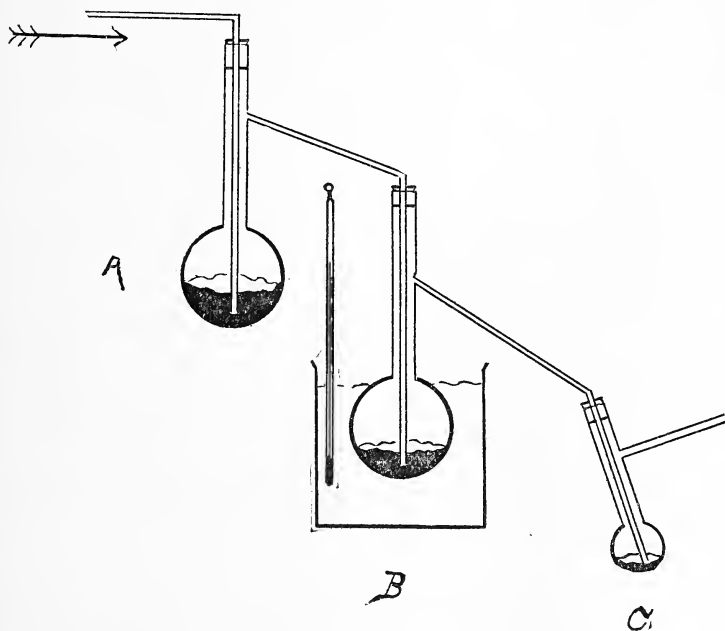


FIGURE 1.

The sulphuric acid employed was the ordinary pure product, containing 98.4 per cent of H_2SO_4 . The apparatus illustrated in the figure was used.

The method employed was to heat the copper with the sulphuric acid (in flask B) gradually in a sulphuric acid bath while

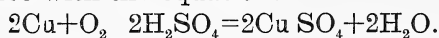
passing a dry current of air or of carbonic anhydride through it. The escaping gas was then tested (in flask C) by suitable reagents, to be described, for sulphuric and sulphurous anhydrides respectively. Flask A contained concentrated sulphuric acid of the ordinary temperature (25°C) to dry the gas, which was usually passed at the rate of about eighty bubbles per minute. The importance of securing absence of dust from the acid being recognized, the interior of the whole apparatus was washed with boiling concentrated sulphuric acid and dried in dustless air.

Experiment I.—Flasks A and B were charged with concentrated sulphuric acid and C with a solution of barium chloride. Air was drawn through the whole in a slow current for fifteen minutes. The solution in C remained clear. B was now very slowly heated while the current of air was maintained.

Before the bath reached 70°C there appeared in C a faint turbidity of barium sulphate, which at the temperature named became distinct. At 60°C the solution remained unchanged, even after passing the air for a long time. Hence sulphuric acid of the given concentration begins to give up sulphuric anhydrides, that is, it begins to dissociate at a temperature lying between 60° and 70°C.

Experiment II.—The apparatus charged as before, with the addition of pure bright copper wire in B, and with highly dilute iodide of starch instead of barium chloride in C. After passing air for several hours at the ordinary temperature, much of the copper had gone into solution and anhydrous copper sulphate had begun to crystallize out, but the iodide of starch, made originally very pale blue, retained its color.

This shows that in the presence of air, sulphuric acid is attacked by copper at ordinary temperatures, but without reduction of the acid. The reaction must take place in accordance with the equation:



Experiment III.—This was like the last, except that the apparatus was filled with carbonic anhydride, and a current of this gas was substituted for air.

The copper was not attacked, and the starch iodide was not decolorized. The temperature of B was now slowly raised, and when it reached 90° the solution in C was bleached. In a similar experiment a solution of dilute sulphuric acid, colored pale straw with potassium bichromate, was used as an indicator for

sulphurous acid in C. In this case the change of color did not occur until the temperature had risen to 108° , the indicator being, as might be expected, less sensitive than the other.

Experiment IV.—Same as III, except that a reagent for both sulphuric and sulphurous acid was used in C.

This reagent was prepared by slightly acidifying a solution of barium chloride with hydrochloric acid and then adding enough potassium permanganate to render the solution pale rose color.

This indicator is capable of showing the presence of considerably less than $\frac{1}{100}$ m. g. of sulphurous acid.

When the temperature of the bath had reached 70°C the solution in C was distinctly turbid with barium sulphate, but its color was unaltered. At 86° it began rather suddenly to bleach, and at 87° it was colorless. Special care was taken in filling B not to get any sulphuric acid on the neck or sides of the flask. A repetition of this experiment gave identical results, the gas being passed at the rate of two to three bubbles per second.

The conclusions to be drawn from this investigation are:

First.—That the dissociation of sulphuric acid of 98.4 per cent. begins to be appreciable at a temperature somewhat below 70° , which may be estimated at about 67° .

Second.—The reduction of sulphuric acid by copper does not begin below 86° , that is, not until the acid contains free anhydride.

The assertion made by Baskerville,¹ that sulphuric acid is reduced by copper at 0° is, therefore, incorrect. He appears to have based the statement, not on any demonstration of the formation of sulphurous acid, but solely on the formation of copper sulphate, which occurs, as I have shown,² in consequence of the presence of air.

A more careful repetition of his experiments under conditions securing entire exclusion of air can but lead him to a different conclusion from that he obtained at first.

The fact adduced by him that under certain conditions cuprous sulphide may be formed by the action of the metal upon sulphuric acid does not allow any conclusions to be drawn respecting the presence of "nascent" hydrogen, since it may be explained perfectly well either by the direct reducing action

¹Journal of the Am. Chem. Soc., 1895, 908.

²Traube has shown the same thing for dilute sulphuric acid. *Ber.* 18, 1888.

of the copper or by Traube's theory which is backed up by almost convincing evidence³.

Stannous chloride will reduce sulphuric acid with formation of hydrogen sulphide and free sulphur, an analogous reaction in which the assumption of "nascent" hydrogen is inadmissible.

³Moritz Traube, *loc. cit.* and *Ber.*, 18, 1877, etc.

CLAYS OF THE INDIANOLA BRICK, TILE AND POTTERY WORKS

L. A. YOUTZ, INDIANOLA.

Analyses of several clays from a brickyard at Indianola have recently been made by me to go into a report of the Geological Survey of Warren county. Though it has been said that a knowledge of the constituents of a clay, determined by a purely chemical analysis, is of very little value to a practical brick-maker, yet in comparing the analyses of these clays and those from other vicinities, it seems that points of great value to the manufacturer are made plain, and points that can be derived from no other source. So I wish to give a few ideas which came to me as I made the comparison, as points, of local interest at least, were, it seems to me, clearly brought out.

In order to get an intelligent idea of the value of this clay for brick and tile it may be helpful to give a short outline of some of the qualities of clay for the various kinds of brick. The quality and character of brick depends, of course, primarily upon the kinds of earth used; the mechanical mixing, drying and burning being important items, however.

The varieties of clay most frequently used for common bricks are three. The so-called blue clays, hydrated aluminum silicates, combined with small quantities of iron, calcium, magnesium and alkalis; sandy clays or loams, and marls which contain a large proportion of lime and magnesium. In addition to these are the clays for special kinds of brick, as fire-brick, pottery, terra cotta, etc. Hydrated silicate of aluminum is infusible even at the most intense furnace heat, but if these be mixed with alkalis, or alkali earths, it becomes fusible, and in

about the proportion of the admixture. So that clays containing more than about 3 per cent of lime can not be made into good brick from this fact, and that the calcium carbonate being reduced to calcium oxide by heat will slack by moisture and the brick then crumble. However, by burning at a higher temperature than is usual the injurious effect of lime can be greatly overcome unless it is in so great quantity as to lower the fusing point too much. The amount of combined water in a clay is a very important item in determining its adaptability for good brick. In a pure hydrated silicate of aluminum so much water will be given off by burning that the brick in going through the sweating process become too soft and run together, or else crack so as to be made much inferior. So all pure clays for brick must be mixed with sand, powdered quartz, powdered brick, gangue, or some such material, in order to alleviate this difficulty. In loams a certain per cent. of lime or similar material needs to be added to act as a flux, as too much sandy material makes the brick brittle. Marls in this country have been, it appears, but little used for brick making, as the lime is supposed to be detrimental. Yet in Europe a very fine malm is made from marls having as high as 40 per cent or more of calcium carbonate. They simply heat the brick probably 200 degrees higher than the ordinary brick. This gives the brick a white color instead of red, the iron and calcium being united with the aluminum as a ferric-aluminum-calcic silicate.

Of the Indianola brick clays, analyses of two samples will be sufficient for our purpose of comparison. The brick are made from a certain small deposit of blue clay, taken probably twenty feet below the surface, mixed with a much larger proportion of a darker colored clay immediately above this blue layer.

The lower strata gave the following analysis from the air dried samples:

Si O ₂	66.779
Al ₂ O ₃	19.525
Fe ₂ O ₃.....	.72
Ca O.....	trace
Loss dried at 100°.....	8.08
Loss by ignition.....	5.48
Total.....	100.584

The sample above this as follows:

Si O ₂	67.85
Al ₂ O ₃ +Fe ₂ O ₃	20 45
Ca O.....	1.19
Mn O.....	trace
K ₂ O.....	trace
Loss dried at 100°.....	3.47
Loss by ignition.....	7.12
Total.....	100.08

It will be seen that in each there is a large per cent. of silica and alumina. The upper containing more free silica, consequently gave a higher per cent of silica and alumina, but contained a considerably smaller per cent. of hygroscopic moisture, The higher loss by ignition in the upper stratum being due doubtless, to a larger amount of organic matter near the surface. Lime was present in the upper stratum in appreciable quantity, and iron in small quantity in each. A trace of manganese oxide in the upper stratum.

From Crossley's "Table of Analyses of Clays" for common brick we take three average samples, which are as follows:

Common brick clay:

Si O ₂	49.44
Al ₂ O ₃	34.26
Fe ₂ O ₃	7.74
Ca O.....	1.48
Mg O.....	5.14
Water and loss.....	1.94
Total.....	100.00

Sandy clay:

Si O ₂	66.68
Al ₂ O ₃	26.08
Fe ₂ O ₃	1.26
Mg O.....	trace
Ca O.....	.84
Water and loss.....	5.14
Total.....	100.00

Marl.—London "Malms."

Si O ₂ +Al ₂ O ₃	43.00
Fe ₂ O ₃	3.00
Ca O.....	46.50
Mg O.....	3.50
Water.....	4.00
Total.....	100.00

Comparing the Indianola clay with these, with the first it is at variance especially in silica, alumina, and oxide of iron. With the second it corresponds very well except in Al_2O_3 and in having more water. But we could not call it a sandy clay. The upper layer contains a little sand, but the lower practically none. To the third there is no comparison.

It seems then as these clays represent the three common classes of brick, that this clay at Indianola must represent a kind which though it may make, as it has proven itself to do, good common building brick, yet it may be adapted to other kinds of brick.

The Stourbridge, England, clays, from which the world-famed fire brick are made, yield, by averaging the analyses of four different clays, the following proportion of materials:

No. 1.

Si O_2 -----	64.95
Al_2O_3 -----	22.92
Fe_2O_3 -----	1.90
Ca O+Mg O-----	.64
$\text{K}_2\text{O}+\text{Na}_2\text{O}$ -----	.37
H_2O loss -----	9.60
Total-----	100.38

Woodbridge fire clay bed, New Jersey, also famous for its quality of refractory clays, as follows:

No. 2.

Si O_2 combined -----	40.50	
Si O_2 free (quartz sand) -----	6.40	46.90
Al_2O_3 -----	35.90	35.90
Ti O_2 -----	1.30	1.30
$\text{K}_2\text{O}+\text{Na}_2\text{O}$ -----	.44	
Fe_2O_3 -----	1.10	1.54
H_2O combined -----	12.80	
H_2O hygroscopic-----	1.50	14.30
Total -----	99.94	99.94

From Trenton, New Jersey:

No. 3.

Si O_2 combined -----	17.50	
Si O_2 free (quartz sand) -----	56.80	74.30
Al_2O_3 -----	18.11	18.11
$\text{K}_2\text{O}+\text{Na}_2\text{O}+\text{Ca O}$ -----	1.07	1.07
$\text{Fe}_2\text{O}_3+\text{H}_2\text{O}$ -----	6.99	6.99
Total -----	100.47	100.47

These three samples of fire brick clays are selected from a list of about 100 analyses of clays taken from various parts of the United States and Europe, and, I think, represent a fair average as to composition. From these it may be seen that in general a large amount of Al_2O_3 and SiO_2 , with small amounts of alkali, or alkali earths, or iron oxide, is characteristic of these highly refractible clays. Further, it seems that a large per cent. of Al_2O_3 over SiO_2 increases the infusibility. However, there seem to be two varieties of fire clay, varying considerably in composition, which make equally good fire brick. One is where the silica is nearly all combined with a percentage of about 40 to 50 per cent, and a large amount of aluminum oxide—probably 25 to 35 per cent.—and water making up the greater amount of the remaining 100 per cent. This clay, of course, as the per cent. of the alumina over the silica and these two over other metallic oxides increases, finally runs into kaolin. The other kind is one where the combined silica is small and the alumina less than in the first case, the combined silica probably not having a much higher percentage than the alumina, the remaining part being made up almost entirely of free silica (quartz sand) and water. No. 2 above illustrates the first and No. 3 the second class.

By comparing the Indianola clays with these it will be seen that the average is essentially the same as No. 1. This being an average of several samples of each of the two classes referred to above, *i. e.*, No. 2 and No. 3. But in the Indianola clays there is but small amount of free silica. This being the case, and from the fact that it is so free from magnesia, lime, potash, and iron oxide, it would seem that this clay would be well adapted to be used as the clay basis of fire brick, and then the necessary amount of free silica (either powdered quartz, glass, or silicious brick dust) be added. By a very careful comparison of all the clays the analyses of which I have, and the qualities of brick made from these, theoretically it seems to me by this means very superior fire brick could be made. The fusibility of bricks made by this method with this clay as far as I know has not been determined. Yet it seems it would be an experiment worth trying, and one which we may attempt at a later date.

I am informed that the pottery made at this plant is not made from the clay at Indianola, but is made from clay taken just above the upper vein of coal at Carlisle, Iowa. I have not analyzed this clay and cannot at present make a comparison.

UNIT SYSTEMS AND DIMENSIONS.

T. PROCTOR HALL.

(Abstract.)[Published in full in *Electrical World* February 7, 1896.]

The three fundamental units of the C. G. S. system are reduced to two when the unit of mass is defined as the quantity of matter which, by its gravitational force, produces at unit distance unit acceleration; and these two to one when the unit of time is defined as the time taken by an ether wave one centimeter long to advance one centimeter. A table is given showing the dimensions of units in each of these three systems, and the advantages of the latter are pointed out.

A MAD STONE.

BY T. PROCTOR HALL AND ERNEST E. FRISK.

Here and there is found a man possessing a pebble for which he claims the remarkable power of preventing hydrophobia when applied to the wound made by a mad dog. We have been unable to find any record of a scientific examination of a mad stone or a scientific test of its properties. This may be partly accounted for by the rarity of the stone, and the high esteem in which they are held by their owners. A popular idea is that they are formed by accretion in a deer's stomach.

Last summer while visiting the Mammoth Chimney mine, eighteen miles south of Gunnison, Col., a prospector called attention to some small pieces of light-colored rock from the mine, which adhered very strongly to the tongue. Some

specimens were secured as a curiosity, and after being properly rounded, to obscure their origin, were recognized by some of the "old inhabitants" as genuine mad stones. Their curative power has yet to be tested, but in all other respects, apparently, their identification is complete.

The fragments removed from the larger specimen were preserved for examination and analysis. The specimen itself is larger than a hen's egg, light gray in color, with darker specks of iron scattered through; distinctly stratified; with no cleavage planes. The luster on a broken surface is resinous, on a worn surface more earthy. Its hardness, considered as a rock is $2\frac{1}{2}$, but the fine powder scratches glass. It is infusible in an ordinary blowpipe flame, and powders easily after ignition.

Under the microscope it appears to be made of flat and irregular transparent granules about 1-500 millimeter thick, some of which are ten times that width, fitted loosely together so as to leave irregular cavities everywhere in communication with each other. The fragments resemble fragments of silicious infusorial shells which are found in large quantities in some parts of the Rocky mountains.

The specimen after remaining some weeks in the air of a dry room (heated by hot air) weighed 70.77 grams. It was placed in distilled water, in which it floated for two or three minutes, boiled for some hours, and allowed to cool. After weighing it was hastily dried with a piece of filter paper and weighed again. Lastly it was dried some hours in an oven at a temperature of 100° to 150° C, cooled in a desiccator, and weighed.

Weight in ordinary dry air.....	70.77 grams.
Weight in water, saturated.....	39.14 grams.
Weight in air, saturated.....	115.00 grams.
Weight in air, dry.....	69.15 grams.

From this data we get:

Volume of rock in the specimen.....	30.01 cc.
Volume of cavities in the specimen.....	45.85 cc.
Total volume.....	75.86 cc.
Specific gravity of rock.....	2.304
Specific gravity of the whole.....	.912
Volume of water held in ordinary dry air.....	1.62 cc.

Some fragments of the stone were pulverized in an agate mortar, fused with sodium and potassium carbonates, and analyzed in the ordinary way. Before fusion the powder was dried at about 150° C. The results are as follows:

	No. 1.	No. 2.
Weight of powder.....	.5882 gram.	.4559 gram.
Si O ₂ found.....	95.53%	96.14%
Al ₂ O ₃ plus traces of Fe ₂ O ₃	4.59%	4.01%
Total	100.12	100.15

The force of adhesion to a wet surface was estimated at 200 grams per square centimeter, or about one-fifth of an atmosphere, but it may be much greater. If applied to a poisoned wound at once it would undoubtedly absorb some of the poison and so assist in the cure. The popular belief in its efficacy has therefore, some foundation in fact.

If more of this rock can be secured it is our intention to test the rapidity of its absorption of moisture from the air when cut in thin slices, with a view to its use as a hygrometer.

The vein in which the specimen was found is twenty feet wide, nearly vertical, and strikes westward. The contents of the vein are chiefly light and dark blue translucent quartzite, mixed with amorphous clay and iron oxide, and bordered by a thin blanket of limestone. Some of the translucent quartzite is mixed with light gray mad stone, as if the firmer portions were formed by fusion of the light gray material. The latter agrees very closely in composition, as well as in appearance, with the silicious shells already mentioned, and was probably formed from them by the internal heat of the vein.

PHYSICAL THEORIES OF GRAVITATION.

T. PROCTOR HALL.

A force which belongs to individual atoms, is independent of chemical and physical conditions, and cannot be altered or destroyed by any known means, must be closely related to the fundamental nature of the atoms. One of the most essential parts in our concept of matter is mass, and the force of gravitation of an atom is proportional to its mass. Mass and gravitation stand, therefore, either as co-effects of the same cause or as cause and effect. The force exerted by each atom at any point decreases in proportion to the increase of the expanding

spherical surface containing the point; following the law of all forces expanding in three-fold space, which may be stated thus: Force \times area of distribution—a constant.

From this fact it is evident that the distribution of the force of gravitation is confined to threefold space; for, since the boundary of a fourfold sphere is a solid, a force expanding in all directions from a point in fourfold space decreases in intensity in proportion to the increase of the boundary, that is to say, in proportion to the cube of the radius, instead of following Newton's law.

Newton's law has been experimentally proved for distances that are very great compared with the diameter of an atom, and to a degree of accuracy limited by errors of experiment. It does not necessarily follow that the law holds with absolute accuracy, or that it holds at all for distances comparable with atomic dimensions. All that we can say is that for distances moderate and great the law expresses the facts as accurately as they have been experimentally determined.

Gravitation is not, like magnetism, polar. In crystals atoms have an orderly arrangement, yet no difference has been found in the weight of any crystal when it is set on end or laid on its side. This fact, along with the complete independence of electric conditions, show that gravitation is neither an electric nor a magnetic phenomenon.

The ether, so far as our knowledge goes, is a homogeneous isotropic continuum. In the conveyance of light and of electric strain it shows the properties of an elastic solid. To planetary motions and to ordinary motions on the earth it offers no appreciable resistance, and may therefore be called a fluid. Michelson and Morley have shown that the ether close to and in the earth moves with the earth, which indicates that the ether does not move among atoms without some resistance corresponding to friction. The existence of an ether strain such as that in a leyden jar also shows that there is a resistance on the part of the ether to the kind of motion that takes place in the electric discharge. Ether has mass, since it conveys energy by waves which have a finite velocity. Lord Kelvin has pointed out that the apparently inconsistent properties of the fluid-solid ether are analogous with the properties of ordinary matter. Pitch or taffy, either of which can be bent or moulded easily by a steady pressure, is shattered like glass by a quick blow from a hammer. The ether in like manner yields easily before

moving bodies whose velocity is relatively small, not exceeding a few hundred kilometers per second, but acts as a solid toward such high velocities as that of light, which is nearly 300,000 kilometers per second. Copper, again, is a familiar example of a metal having nearly perfect elasticity within a certain limit of strain. Beyond that limit it yields to pressure like a fluid. The ether shows the same combination of properties with a wider limit of strain. Ether in a vacuum will bear a very great electrical strain without yielding; so that the most perfect vacuum attainable is an all but perfect non-conductor; but if atoms be present the ether gives way to the stress and a current passes very much more readily. This indicates that there is some sort of discontinuity at or near the surface of the atoms.

One of the oldest theories of gravitation was proposed by Le Sage and elaborated by him for a lifetime. He supposed the atoms to have an open structure, something like wire models of solid figures, and to be exposed to a continuous storm of exceedingly minute "ultramundane corpuscles" which he assumed to be flying about in all directions with inconceivable velocity. Two atoms shelter each other from this storm in direct proportion to the quantity of matter in each and inversely as the square of their distance apart, and are therefore driven together in accordance with Newton's law. The ultramundane corpuscles are supposed so small that no atomic vibrations corresponding to heat or light are caused by their impact.

Le Sage's theory is unsatisfactory because it takes no account of the ether, which for such high velocities acts as a solid and would bring the little flying corpuscles to comparative rest in a small fraction of a second.

Kelvin has proposed a modification of Le Sage's theory in order to accommodate it to the existence of the ether. He first showed that vortex rings have some of the properties of elastic solids, and in a perfect fluid would be indestructible; then suggested that atoms may be vortex rings of ether, and the ultramundane corpuscles very much smaller vortex rings having high velocities of translation. In order to account for the permanence of atoms and corpuscles, this view presupposes a practically frictionless fluid ether, which does not at all correspond with the actual ether.

Maxwell, after deducing the mathematical theory of electricity from the hypothesis of ether strain, showed that gravi-

tation also could be accounted for on a similar hypothesis, and that the properties required for the propagation of gravitation are similar to those exhibited by the ether in the phenomena of light and electricity. This theory is the only one that is in harmony with what is known of both gravitation and the ether. It is simple, and makes no assumptions whatever regarding the nature of matter or of atoms. It is incomplete in that it leaves the nature of the strain undetermined.

The non-polar character of gravitation, its symmetry in every way about the atom, reduces to two the possible kinds of strain required by Maxwell's hypothesis. These are displacements of ether radially (1) outward from or (2) inward toward the atom. Assuming, as is customary, that the ether is incompressible, the radial displacement over a spherical surface about the atom is constant; and therefore the displacement and the intensity of the stress at any point varies inversely as the square of its distance from the atom. It is not necessary to suppose, either, that the atom itself is spherical or that the displacements in its immediate vicinity are directed toward or from a single point; for at the distance of a single centimeter from the atom the surface of equal displacement must be so nearly spherical that the most accurate observation now possible would fail to detect any irregularity. Possibly variations in the form of the atom or in the direction of displacement immediately around it may be the cause of the chemical properties of the atom, since these are apparent only at very small distances from it.

For the sake of clearness let us suppose that outward displacement of the ether is caused by the insertion of a quantity of matter, an atom, at any point. Draw a cone having the center of displacement for its vertex. Any small element in this cone is by its outward displacement shortened and widened; so that there is on each end of the conical element a pressure, and in all directions perpendicular to the pressure a tension due to the stretching of the expanded spherical shell containing the element.

Suppose, also, for the sake of clearness, that inward displacement is produced either by cutting out small portions of the ether and leaving holes (atoms) toward which the strain is directed, or by condensing small portions of the ether into atoms. An element of the cone is by its inward displacement lengthened and made narrower, and has a tension on each end and a pressure in all directions perpendicular to the tensions.

The strain in each case extends to infinity, or as far as the ether extends. If the displacement of ether were prevented from extending on one side by a rigid imaginary wall, the whole strain on that side would take place between the atom and the wall, and would be more intense than on the opposite side. The atom would tend to move in such direction as to decrease the intensity of the strain, namely, from the wall if the displacement were outward, toward the wall if the displacement were inward. By the same reasoning two atoms repel each other if the displacement is outward, and attract if it is inward. The law of gravitation is thus explained on the hypothesis that each atom is accompanied by an inward displacement of the surrounding ether, proportional in amount to the mass of the atom.

Minchin (Statics, fourth edition, vol. 2, p. 475,) by a course of mathematical reasoning has reached the same conclusion.

If the atoms be regarded as cavities, the mass of an atom is represented by the quantity of ether removed, which represents also the volume of the atom. Since atomic volume is not proportioned to atomic weight, the cavity-atom hypothesis must be abandoned.

On the condensation hypothesis the mass of an atom is the quantity of ether condensed, its volume the space occupied on the average by the condensed mass which may have any kind of irregularity of form.

This hypothesis implies that all atoms are built out of the same original stuff, and is in this respect similar to but not identical with Prout's hypothesis. The fact that all atoms attract with forces proportional to their masses shows that all atoms possess the same kind of mass, and are therefore likely to consist of the same sort of stuff.

Valence, selective affinity, electric and other peculiarities of atoms, must, if this hypothesis of gravitation be correct, find their explanation in the form and density of the atom, the distribution of its stuff in space, which can be expressed as a function of the three space co ordinates; together with the laws of energy, which express the relations of the atom to the ether. The field of force about an atom is also capable of representation by a function of the space co-ordinates such that when the distance r from the atom is relatively great the equipotential surfaces are very nearly spheres.

Stress in its ultimate analysis is probably dynamic. If so, the maintenance of the field of strain about an atom as it moves presents no greater difficulty than the maintenance of the field of light about a moving candle, or of the field of sound about a moving bell.

The propagation of such ether strains as occur in light, electricity and magnetism is very greatly influenced by the material substances present in the strained medium. It is not probable that the gravitational strain differs from others in this respect, and we may reasonably hope to find some inductive phenomena in connection with gravitation. A feasible plan is to surround a delicately poised mass by a thick pair of hemispheres (which may be hollow for liquids), and note with a refractometer any change of position, which, since the attraction of a sphere at a point within it is zero, will be due either to induction or to irregularities of the sphere. Errors due to irregularities may be readily eliminated by rotating the sphere.

THE LE CLAIRE LIMESTONE.

BY SAMUEL CALVIN.

The Le Claire limestone constitutes the second stage of the Niagara formation as it is developed in Iowa. The first or lower stage has been called the Delaware, from the fact that all its varying characteristics are well exhibited in Delaware county. The Delaware stage embraces many barren beds and presents a very great number of phases, but at certain horizons it abounds in characteristic fossils. The typical faunas of this lower stage embrace such forms as *Pentamerus oblongus* Sowerby, *Halysites catenulatus* Linnæus, *Favosites favosus* Goldfuss, *Strombodes gigas* Owen, *Strombodes pentagonus* Goldfuss, *Ptychophyllum expansum* Owen, and *Diphyphyllum multicaule* Hall. The beds of the Delaware stage furthermore contain large quantities of chert.

The Le Claire stage of the Niagara follows the Delaware. The exact line of separation between the two stages has not been, and probably cannot be, definitely drawn. There are

massive, barren, highly dolomitized aspects of both stages that, taken by themselves, cannot be differentiated in the field. Under such circumstances the observer must work out the stratigraphic relations of the particular group of strata under consideration before referring it to its place in the geological column. In general the Le Claire limestone is a heavy bedded, highly crystalline dolomite. It contains scarcely any chert, and in the lower part there are very few fossils. There are occasionally a few specimens of *Pentamerus*, of the form described as *Pentamerus occidentalis* Hall, and the principal coral is a long, slender, tortuous *Amplexus* which is represented only by casts of the vacant or hollow parts of the original corallum. On account of the complete solution of the original structure, the spaces occupied by the solid parts of the corallum are now mere cavities in the limestone. In the upper part of the Le Claire stage small brachiopods abound. They belong to the genera *Homeospira*, *Trematospira*, *Nucleospira*, *Rhynchonella*, *Rhynchotrepa*, *Atrypa*, *Spirifer*, and probably others. In most cases the fossils have been dissolved out, leaving numerous cavities. The calcareous brachial apparatus of the spire-bearing genera is often the only part of the original structure represented. No statement can well give any idea of the numbers of the small shells that crowded the sea bottom near the close of the Le Claire stage, nor of the corresponding number of the minute cavities that are now so characteristic a feature of this portion of the Le Claire limestone. In some localities in Cedar county the small brachiopods of this horizon are represented by very perfect casts that were formed by a secondary filling of the cavities left by solution of the original shell. The external characters are thus fairly well reproduced.

Compared with the beds of the Delaware stage, the Le Claire limestone as a rule lies in more massive ledges, it is more completely dolomitized, and its fracture surfaces exhibit a more perfect crystalline structure. It contains an entirely different fauna, a fauna in which small rhynchonelloid and spire-bearing brachiopods are conspicuous. Its fossils are never silicified, and, in marked contrast with some portions of the Delaware, its upper part at least is notably free from chert. The Le Claire limestone is the lime burning rock of Sugar Creek, Cedar Valley, Port Byron, and Le Claire. Wherever it occurs it furnishes material for the manufacture of the highest quality of lime.

With respect to their distribution the strata of this stage are well developed at Le Claire in Scott county. They are seen in the same stratigraphic relation at the lime kilns on Sugar creek and at Cedar Valley in Cedar county. They occur beneath the quarry stone at and near Stone City, Olin, and Hale in Jones county. They are again seen at numerous points west of the Jones county line in Linn. Indeed they are somewhat generally, though by no means universally, distributed in the east central part of Scott, southwestern parts of Clinton, western Cedar, and the southern parts of Jones and Linn. They seem to be limited to the southwestern corner of the Niagara area. A line drawn from the mouth of the Wapsipinicon through Anamosa would mark approximately their northeastern limits.

The Le Claire limestone is in some respects unique among the geological formations of Iowa. In the first place it varies locally in thickness, so much so that its upper surface is exceedingly undulating, the curves in some places being very sharp and abrupt. In the second place it differs from every other limestone of Iowa in frequently exhibiting the peculiarity of being obliquely bedded on a large scale, the oblique bedding often affecting a thickness of fifteen or twenty feet. The phenomena suggests that during the deposition of the Le Claire limestone the sea covered only the southwestern part of the Niagara area, that at times the waters were comparatively shallow, and that strong currents, acting sometimes in one direction and sometimes in another, swept the calcareous mud back and forth, piling it up in the eddies in lenticular heaps or building it up in obliquely bedded masses over areas of considerable extent. The oblique beds observe no regularity with respect to either the angle or direction of dip. Within comparatively short distances they may be found inclining to all points of the compass. Again the waters at times were quiet, and ordinary processes of deposition went on over the irregular sea bottom, the beds produced under such circumstances conforming to the undulating surface on which they were laid down. In some cases these beds were horizontal as in the upper part of the section illustrated in plate 1, while in other cases they were more or less flexuous and tilted as seen in the left bank of the Wapsipinicon above Newport. (Figure 2.)

Professor Hall accurately describes some of the variations in the inclination and direction of dip in the Le Claire limestone



FIGURE 1. Exposure of LeClaire limestone at the Sugar creek lime quarries, Cedar county, Iowa. The limestone is obliquely bedded in the lower part of the section and horizontally bedded above. The same fauna occurs in both sets of beds. Oblique beds dip southeast.



FIGURE 2. Oblique beds of LeClaire limestone, dipping northeast, in west bank of Mississippi river, one-half mile below LeClaire, Iowa.

as seen at Le Claire*, but he assumes that the inclination of the beds is due to folding and uplift subsequent to their deposition. On this assumption the Le Claire limestone would have a thickness of more than 600 feet, whereas the maximum thickness does not exceed 80 feet, and the average over the whole area is very much less. Prof. A. H. Worthen† studied this limestone at Port Byron, Ill., and Le Claire, Iowa, and describes it as “presenting no regular lines of bedding or stratification, but showing lines of false bedding or cleavage at every conceivable angle to the horizon.” He assigns to these beds a thickness of



FIGURE 2. Inclined undulating beds of the Le Claire stage near Newport, Iowa.

fifty feet, but he offers no explanation of what he calls “false bedding or cleavage.” In White’s report on the geology of Iowa‡ the oblique bedding seems to have been taken as evidence that a line of disturbance crossed the Mississippi river at Le Claire with a direction nearly parallel to the Wapsipinicon valley. This apparent disturbance was last recognized about three miles west of Anamosa. The angle of dip it is said has reached in some places twenty-eight degrees with the horizon. McGee in discussing the *Regular Deformations of Northeastern Iowa*§ quotes Dr. White on the Wapsipinicon line of disturbance

* Rept. on the Geol. Surv. of the State of Iowa, Hall and Whitney, vol. I, part I, pp. 73-74. 1858.

† Geol. Surv. of Ill., vol. I, p. 130. 1865.

‡ Rept. on the Geol. Surv. of the State of Iowa, Charles A. White, vol. I, p. 133. 1870.

§ Pleistocene history of Northeastern Iowa, p. 340. 1891.

and accepts the observations on which the statement is based as evidence of a synclinal fold extending from Le Claire to Anamosa. White's observations appear to have been made only at the two points mentioned. At both places the strata seem to be inclined at a high angle. On the assumption that the inclination of the strata indicates orogenic disturbance, the conclusion that the disturbed beds were parts of the same fold was very natural. There is, however, no fold, nor is there any line of disturbance. In the whole Niagara area southwest of the line which marks the limit of the Le Claire limestone the phenomena seen at Le Claire and west of Anamosa are repeated scores of times and in ways that defy systematic arrangement. The beds incline at all angles from zero to thirty degrees, and even within short distances they may be found dipping in every possible direction. Twenty miles southwest of the line supposed to be traversed by the synclinal fold, for example at the lime kiln on Sugar creek, along the Cedar river above Rochester, at Cedar Valley, as well as at many intermediate points distributed promiscuously throughout the area of the Le Claire limestone, the beds stand at a high angle, and the multiplicity of directions in which they are inclined, even in exposures that are relatively near together, is wholly inconsistent with the idea of orogenic deformation. The beds are now practically in the position in which they were laid down in the tumultuous Niagara sea. The principal disturbances they have suffered have been the results of epeirogenic movements which affected equally the whole region over which these limestones are distributed, as well as all the adjacent regions of the Mississippi valley.

The exposures at Port Byron and Le Claire present some interesting features that are not seen so well at any of the exposures farther west. In the first place, the lime quarries at Port Byron show the characteristic oblique position of the strata, and at the same time they demonstrate that the oblique bedding is real and not a mere deceptive appearance due to cleavage of a mass of sediment that was originally built up regularly and evenly on a horizontal base. As in other groups of strata, there are faunal and lithological variations when the beds are compared one with another. These varying characteristics do not intersect the beds in horizontal planes as they would if the present bedding were due to cleavage of a mass that had risen vertically at a uniform rate, but they follow the



FIGURE 1 Thin-bedded LeClaire limestone overlying the phase represented in Plate I, figure 2, as seen on west side of Main street, LeClaire, Iowa. At this point sub-marine erosion removed portions of certain beds, and the space so formed was subsequently filled with a second set of beds which overlapped obliquely the eroded edges of the first.

individual layers in their oblique course from top to bottom of the exposure. The facts confirm the statement that the beds were deposited one by one in the position in which we now find them.

On the west side of the Mississippi, south of Le Claire, the usual oblique bedding is seen in the bank of the river, below the level of the plain on which the lower part of the town is built. The individual beds, as in all the characteristic exposures of this formation, range from eight to twelve inches in thickness. Above the level of the beds exposed in the river bank there is another series of Le Claire beds that depart somewhat from the ordinary type. Near the base of this second series the layers are thick and the rock is a light gray, porous, soft, non-crystalline dolomite. These grade up into thinner and more compact beds, but the lithological characters are never quite the same as those of the more typical beds at a lower level. The soft, porous gray-colored beds contain casts of *Dinobolus conradi* (Hall). The same species ranges up into the harder beds, but the characteristic fossils above the soft, porous layers are casts of small individuals of *Atrypa reticularis* and a small, smooth-surfaced *Spirifer*. The layers become quite thin in the upper part of the Le Claire. They show many anomalies of dip, but, so far as observed, they do not as a rule stand at as high angles as do the harder and more perfectly crystalline beds of the lower series. The existence, however, of tumultuous seas is no less clearly indicated at this horizon than in the lower beds that pitch at greater angles. In the town of Le Claire, on the west side of the main street, there is evidence of the erosion of the sea bottom by currents, and subsequent filling of the resulting channels with material of the same kind as formed the original beds. In eroding the observed channel some of the previously formed layers were cut off abruptly, and in refilling the space that had been scooped out the new layers conformed to the concave surface and lapped obliquely over the eroded edges of the old ones.

The angle at which the lower, more highly inclined beds stand never exceeds twenty-eight or thirty degrees; that is, it never exceeds the angle of stable slope for the fine, wet, calcareous material of which the strata were originally composed.

The Le Claire limestone is, as a whole, sharply set off from the deposits of the Delaware stage by its hard, highly crystalline structure, its freedom from chert, its easily recognized

fauna, and its record of anomalous conditions of deposition. In the field the distinction between the Le Claire and the Anamosa stages are even more easily recognized, though faunally the two stages are intimately related. In the Anamosa stage oblique bedding is unknown; lithologically the rock is an earthy, finely and perfectly laminated dolomite, not highly crystalline in its typical aspect, and too impure for the manufacture of lime. It may be quarried in symmetrical blocks of any desired dimensions, while the Le Claire limestone breaks into shapeless masses wholly unfit for building purposes. The quarry beds of the Anamosa stage are quite free from fossils, but along the Cedar river in Cedar county the brachiopod fauna of the upper part of the Le Claire reappears in great force in a stratum four feet in thickness, up near the top of the formation. The beds of the Anamosa stage are very undulating, and dip in long, graceful, sweeping curves in every possible direction. The knobs and bosses and irregular undulation developed on the sea bottom as a result of the peculiar condition prevailing during the Le Claire age, persisted to a greater or less extent after the age came to an end, and it was upon this uneven floor that the Anamosa limestone was laid down. The puzzling flexures of the Anamosa limestone, and the puzzling variations in altitude at which it occurs, were largely determined by irregularities in the upper surface of the Le Claire formation.

THE BUCHANAN GRAVELS: AN INTERGLACIAL DEPOSIT IN BUCHANAN COUNTY, IOWA.

BY SAMUEL CALVIN.

About three miles east of Independence, Iowa, there are cross-bedded, water-laid deposits of sand and gravel of more than usual interest. The beds in question occur near the line of the Illinois Central railway. The railway company indeed has opened up the beds and developed a great gravel pit from which many thousands of carloads have been taken and used as ballast along the line.

Overlying the gravel is a thin layer of Iowan drift, not more than two or three feet in thickness, but charged with gray

granite boulders of massive size. Some of these boulders may be seen perched on the very margin of the pit, and some have been undermined in taking out the gravel and have fallen to the bottom. The surface of the whole surrounding region is thickly strewn with Iowan boulders. It is evident that the Iowan drift sheet was spread over northeastern Iowa after the gravels were in place.

These sands and gravels are now so incoherent that they may be excavated easily with the shovel, and yet there is no evidence that the glaciers that transported the overlying boulders and distributed the Iowan drift cut into them, or disturbed them, to any appreciable extent. The Iowan ice sheet was probably thin, and all the loose surface materials in front of its advancing edge were frozen solid. The thickness of the gravels is somewhat variable, owing to the uneven floor upon which they were deposited, but it ranges from fifteen to twenty feet. The beds have been worked out in places down to the blue clay of the Kansan drift.

Throughout the gravel bed, but more particularly in the lower portion of it, there are numerous boulders that range in diameter up to ten or twelve inches. These boulders are all of the Kansan type. Fine grained greenstones predominate. Proportionally large numbers of them are planed and scored on one or two sides. Those that are too large to be used as ballast are thrown aside on the bottom of the excavation, and in the course of a few seasons many of the granites and other species crumble into sand. The contrast between the decayed granites of the Kansan stage and the fresh, hard, undecayed Iowan boulders in the drift sheet above the gravels, is very striking. Many of the boulders from the gravels are coated more or less with a secondary calcareous deposit, a feature not uncommon among boulders taken directly from the Kansan drift sheet in other parts of Iowa.

As to their origin the Buchanan gravels are made up of materials derived from the Kansan drift. As to age they must have been laid down in a body of water immediately behind the retreating edge of the Kansan ice. There are reasons for believing that the Kansan ice was vastly thicker than the Iowan, but the temperature was milder, and so when the period of melting came enormous volumes of water were set free. That strong currents were developed is evidenced by the coarse character of the material deposited as well as by the conspicuous

cross bedding that characterizes the whole formation. Some of the larger boulders found at various levels throughout the beds were probably not directly transported by currents, but by floating masses of ice. While, therefore, the gravels lie between two sheets of drift, and for that reason may be called interglacial, probably Aftonian, they yet belong to the time of the first ice melting, and are related to the Kansan stage of the glacial series as the loess of northeastern Iowa is related to the Iowan stage.

While the Illinois Central gravel pit is the typical exposure of the Buchanan gravels, the same beds are found widely distributed throughout Buchanan, Linn, Jones, Delaware and probably other counties. One exposure that has been utilized for the improvement of the county roads occurs on the hilltop a mile east of Independence. Another, used for like purposes, is found a mile and a half west of Winthrop. The county line road northeast of Troy Mills cuts through the same deposit. Throughout the region already indicated there are many beds of similar gravels, but in general they are so situated as not to show their relations to the two beds of drift.

The Buchanan gravels, it should be remembered, represent the coarse residue from a large body of till. The fine silt was carried away by the currents and deposits of it should be found somewhere to the southward. It may possibly be represented, in part at least, by the fine loess-like silt that forms a top dressing to the plains of Kansan drift in southern Iowa and regions farther south.

RECENT DISCOVERIES OF GLACIAL SCORINGS IN SOUTHEASTERN IOWA.

BY FRANCIS M. FULTZ.

The discoveries of localities showing glacial scoring in southeastern Iowa have been somewhat numerous during the last few years. In a paper presented before this body a year ago¹ I called attention in detail to the different known exposures

¹Glacial Markings in Southeastern Iowa. Proc. Ia. Acad. Sci., Vol. II, p. 213. Des Moines, 1895.



FIGURE 1. General view of the typical exposure of the Buchanan gravels.



FIGURE 2. Near view of the Buchanan gravels.



FIGURE 1. Abandoned part of gravel pit.



FIGURE 2. Field immediately north of the gravel pit, showing large numbers of Iowa boulders.

of glaciated rock in this region, and pointed out that the testimony they gave was unanimous as to the southeastern movement of the ice sheet. Since then another exposure has been located that seems to bring conflicting testimony.

This locality is the joint discovery of Mr. Frank Leverett and myself. It is situated on the lot at the northeast corner of the intersection of Court and Prospect streets in the city of Burlington. Some quarrying had been done by blasting out the level rock floor. Everywhere on the margin of the hole thus formed may be seen the finely striated and grooved surface. On the east side a patch, 6x8 feet, was cleaned off and a finely striated surface brought to view. The direction of the striæ, taken with compass and corrected, was S. 79° W. This would indicate an almost due westerly movement, which is in direct variance with that shown by all other discoveries of glaciated rock in this region. If *direction of striæ* alone were taken into consideration, then it might be claimed that the ice movement in this case also was towards the east. But a close and critical examination shows that all the accompanying phenomena point to a westerly trend; *e. g.*, the indicated movement of the ice around and over a prominence, and down into and out of a depression.

This is new and important evidence that the Illinois lobe of the great ice sheet crossed the Mississippi river and invaded Iowa. It will be remembered that I presented a paper on this subject at our last meeting.² The evidence on which the claim was based was the presence, on the Iowa side, of boulders of Huron conglomerates. I was convinced that this westward movement was not the *latest* in this region, but that the ice moving from the northeast was the last to hold possession of the west bluff of the Mississippi; and I so put forward in the paper. Mr. Frank Leverett, who has made an exhaustive study of this question, is of the opinion that the Illinois ice sheet was the last to invade this portion of Iowa, and that the movement extended to some twenty miles west of the river. This recent discovery of glacial scoring certainly strengthens his theory. For it is situated at such an elevation that any ice sheet passing over would be almost certain to leave its impress; and therefore the striæ we now find are very apt to be those made by the latest invasion.

²Extension of the Illinois Lobe of the Great Ice Sheet Into Iowa. Proc. Ia. Acad. Sci., Vol. II, p. 209. Des Moines, 1895.

However, I am not yet fully convinced. Of the somewhat numerous discoveries of glacial scorings in this region, nearly all are on the very brow of the west bluff bordering the Mississippi flood plain, where they would offer the best possible opportunity for erosion. It would therefore seem that they ought to be the records of the *very latest* invasion. And all these, without a single exception, show southwestward movement.

SOME FACTS BROUGHT TO LIGHT BY DEEP WELLS IN DES MOINES COUNTY, IOWA.

BY FRANCIS M. FULTZ.

During the past year a number of deep wells were sunk in Des Moines county. Some of them reached such extraordinary depths before touching rock, or without touching rock at all, as would clearly show the presence of buried river channels.

In a paper presented before this society a year ago I stated that the preglacial and present drainage systems in this region were practically the same. From facts recently brought to light I must necessarily change that opinion. To what extent remains yet to be seen.

My attention was first called to the presence of buried water courses in this locality by Mr. Frank Leverett, of the United States Geological Survey, who has collected a large mass of data on the glacial phenomena of this region. He has already given us a general discussion of the preglacial conditions of the Mississippi basin¹; and in the course of time we may hope for further and more detailed contributions along the same line.

The deep wells in question are located some eight or nine miles north of Burlington. One is on the farm of L. Aspelmeier, near Latty station. It is 233 feet deep, and penetrates the rock but two feet. Unfortunately there was no record kept of the character of the deposits passed through, which is also true of the other wells to be mentioned further on. Therefore the details are somewhat meager. As nearly as could be determined the till continued to a depth of 188 feet, where a gravel

¹ Journal of Geology, p. 740, Vol. III, No. 7, 1895.

bed of several feet in thickness was passed through. In this gravel deposit well preserved bones were found. They were crushed into fragments by the drill, but a number of pieces, from one inch up to three inches long, were brought up in the wash. I saw these fragments about a week after they were discovered, and they had the appearance of having belonged to a living animal not longer ago than that time. Mr. Jennings, of New London, Iowa, who had charge of the drilling, told me that the bones had quite a fetid odor when first brought up. It was difficult to determine from what particular bones the fragments were, but I would place them as parts of the leg bones of some animal of slender build. Below the gravel bed the drill passed through a black deposit, which the well drillers call "sea mud," and which rests directly upon the blue shale of the Kinderhook, 231 feet below the surface.

A quarter of a mile north of the Aspelmeier well the rock bed is reached at a depth of less than thirty feet. It is the hard, compact limestone of the Upper Burlington. This shows a drop of over 200 feet in within a distance of 80 rods.

Half a mile south of the Aspelmeier well, on the farm of Fred Timmerman, there is another deep well which reaches a depth of 184 feet without striking rock. The bottom of the well is in a gravel deposit, which partakes of the nature of a forest bed. From it much woody matter was brought up.

A half mile still further south, making a mile south from the Aspelmeier well there is still another deep well. It is on the place of H. C. Timmerman. It reaches a depth of 188 feet without striking rock. It likewise terminates in a gravel bed containing much woody matter. In the two Timmerman wells the water rises seventy-five feet. When last heard from the Aspelmeier well was not furnishing a satisfactory supply.

These wells indicate an old channel of great depth, and of not less than a mile and a quarter in width. The width is probably much greater. Mr. Frank Leverett suggests that this ancient river bed was the water outlet of part of the territory now drained by the Skunk river.

RECENT DEVELOPMENTS IN THE DUBUQUE LEAD AND ZINC MINES.

BY A. G. LEONARD.

During the past year or two there have been some important developments in the Dubuque district. New lead mines have been opened up, new ore bodies have been discovered, and the Durango zinc mine, the largest in the state, has been still further developed.

About one mile west of the city is located the mine of the Dubuque Lead Mining company, which has been worked only about a year and a half. It is on the west end of the old level range which has been followed for nearly three miles and has yielded considerable ore from various points along its length. When the mine was visited in November, 1895, there were seventy-five men employed and the place presented a lively appearance. The three shafts are 210 feet deep with a steam hoist on one and gins on the other two. The company has just erected a concentrator at the mine for the purpose of crushing and cleaning the ore. This was made necessary by the fact that in this mine much of the Galena occurs scattered through the rock, sometimes in particles of considerable size. The limestone is crushed and the lead then separated from it by washing. The ore-bearing dolomite forms a zone from two to four feet wide and contains an abundance of iron pyrites. This latter mineral is often found here crystallized in beautiful octahedrons with a length of from one-fourth to three-fourths of an inch. Besides being disseminated through the rock the Galena occurs in large masses in what is probably the fourth opening, and it likewise fills the crevice above for some distance. The ore body is apparently an extensive one; 700,000 pounds of lead have already been raised. Work in this mine is made possible only by the constant operation of a steam pump which keeps the water below the opening where the ore occurs and thus allows the miners to reach the deposits.

The extensive zinc mine at Durango, five miles northwest of Dubuque, has several points of special interest. The timber range on which the diggings are located was once well known as a large lead producer. The range has a width of 100 feet, and is formed by three main crevices, with a general direction S. 80° E. The openings occur ninety feet below the crown of the hill, and where they are enlarged the three fissures unite in caverns of immense size. In these openings the lead occurred, and above them, extending to the surface, the hill is filled with zinc carbonate. The zinc is known to extend also below the level of the lead. The mine is worked by means of an open cut extending through the hill, with a width of forty feet and a depth of about eighty feet. The crevices are more or less open up to the surface. Several can be seen in the face of the cut, and in them the ore is most abundant, though it is also found mixed all through the fractured limestone. The strata have been subjected to more or less strain, possibly owing to the large caves below, and are broken into fragments. The carbonate is found coating these pieces and filling the spaces between, occurring also, as stated, in the open crevices. The latter have a width of from one to two feet. In working the mine the larger masses are blasted and the smaller ones loosened with the pick. The ore is removed from the rock, the latter is carted off to the dump, and the dry bone, mixed with more or less waste material, is carried to a neighboring stream. Here it is washed by an ingenious contrivance which thoroughly frees the ore from all sand and dirt. The method was invented by Mr. Goldthorp, superintendent of the mine, and is quite extensively used about Dubuque. An Archimedes screw, turned by horse power, revolves in a trough through which a stream of water is kept flowing. As the screw revolves it gradually works the ore up the gentle incline, while the water runs down and carries with it all sand and dirt. Afterwards the dry bone is picked over by hand and the rock fragments thus separated.

During the past season eighteen men were employed at the mine and the daily output was from fifteen to eighteen tons of ore. This would mean a yield of over 2,500 tons for six months, and is probably about the annual production of the mine during the last few years.

Most of the zinc mines have been closed for nearly two years on account of the low price paid for the carbonate, the average being only \$5 to \$6 per ton the past year. About 800 tons

were, however, sold at these figures. There are very large quantities of ore in sight in these mines, as even a brief inspection clearly shows, and they are capable of yielding thousands of tons for some years to come.

The output of the mines for the past year can be given only approximately. They have produced about 750,000 pounds of lead and from 3,000 to 3,500 tons of zinc. But it must be remembered that, as already stated, most of the zinc mines were closed during the past season. They are easily capable of yielding from 8,000 to 10,000 tons of ore annually.

THE AREA OF SLATE NEAR NASHUA, N. H.

BY J. L. TILTON.

OUTLINE.

Maps of Crosby and Hitchcock.

The area briefly outlined.

Description of the slate area.

Description of the rocks.

• Section from Nashua northward.

Section along the Massachusetts line.

Section west of Hollis Center.

Section east from Runnells Bridge, and southeast from Nashua.

Attempt to harmonize descriptions of Crosby and Hitchcock.

Structure.

Dip, strike, general section.

Evidences of faults.

Cause of metamorphism.

Maps of Crosby and Hitchcock.—Crosby's map of eastern Massachusetts represents an area of slate, or argillite, as it is termed, running from Worcester through Lancaster and Pepperell, to the New Hampshire state line. The eastern part of this argillite, two and one-fourth miles wide on the map, but four miles wide according to the text,* continues north into New Hampshire just west of the Nashua river. On the east of the argillite lies mica schist in an area very narrow (three-fourths of a mile) near the state line, but much wider toward the southern part of the township of Dunstable. On the west

*Crosby's "Geology of Eastern Massachusetts," p. 137.

of the argillite lies gneiss close to the state line, but mica schist a little farther southwest (in Townsend).

Hitchcock's geological map of New Hampshire (Rockingham Sheet) represents an island of gneiss extending from Mine Falls to a mile south of the Massachusetts line near Hollis Station (occupying a part of the area where Crosby locates argillite). This island lies in "Rockingham Mica Schist," extending along the northwest side as an area three and three-fourths miles wide, on the average, and along the southeast side as an area two and a half miles wide. Both these areas of mica schist are represented as continued toward the northeast across the Merrimac river and southwest into Massachusetts.

It is the object of this paper to mark out and describe the slate rock in the vicinity of Nashua (Crosby's argillite, or the northern of the two areas marked by Hitchcock as mica schist).

The Area Briefly Defined.—The slate rock is found to lie in an area six miles wide extending northeast-southwest, just northwest of the Nashua river.

Along the southeast of this area the contact between the slate and the adjacent schist and gneiss extends from Runnells' bridge in a northeasterly direction parallel with the general course of the Nashua river as far as Nashua, where the river leaves the vicinity of the contact. In the city of Nashua the contact extends northwestward in a line between Shattuck's ledge and the reservoir.

Along the northwest of this slate area the boundary-line extends from where Gulf brook crosses the slate line, northeastward through the valley just east of Proctor Hill, near Long pond, Pennichuck pond and Spaulding's pond (or Reed's pond, as it is called locally) and crosses the Merrimac river a mile below Thornton's ferry. This line is not perfectly straight but curved slightly with the convex side to the northwest. Just north of Gulf brook the line curves somewhat suddenly toward the southwest, passing between the two exposures half a mile northeast of the mouth of Gulf brook.

Southeast of Nashua no slate was found in the area represented on Hitchcock's map as a branch of this slate there marked "Rockingham Mica Schist."

General Description of the Slate Area.—The area of slate is marked by an extent of lowland occupied partly by swamps

and ponds.* It contains the Nissitisset river, Flint pond, Long pond, Parker's pond, Pennichuck pond, Round pond and Spaulding's pond, besides a large area of swamp. The southeastern part of the slate area is largely occupied by the present valley of the Nashua.

Within this area the hills of slate rise in ridges to a height of one hundred feet above the adjacent lowland. They do not form continuous ridges, nor does their general direction conform to the direction of strike. This general direction is N. 70° E., while the strike is on the average N. 57° E., though the strike varies a few degrees even in strata but a few feet apart, as the rock is much contorted. These hills are low in contrast with the hills in the gneiss and schist area adjoining. From the top of Long Hill, a hill of the Monadnock type just south of Nashua, these slate hills appear below the Cretaceous peneplain.

The valleys between these hills, even the hills themselves, are mantled with drift, and the river valleys deeply covered with washed drift; but further reference to this important feature is here omitted as not a part of the problem under consideration.

Description of the Rocks.—The character of the rocks and the relation of them one to another is perhaps best seen along a line from Shattuck's ledge, Nashua, northwestward. At Shattuck's ledge, the rock is gneiss in part heavy, in part quite schistose.

At the reservoir, three quarters of a mile west, occurs slate with bands of graphite. Northwest for three miles the rock is a slate very much crushed and crumpled, and in the northern part of this area, a shaly slate interbedded with gneiss. The dividing lines, then between the slate and the schist, and between the schist and the gneiss, are not definitely marked lines, but are intermediate places in a series of gradations.

Similar gradations from slate through schist to gneiss are to be found in the southwestern part of the area near the confluence of Gulf brook and Nissitisset river. Here, south of the Massachusetts line, the slate is both shaly and quartzose. Just north of the Massachusetts line quartz veins are very marked in a dark schistose rock. This same structure is found in a railroad cutting near by, revealing in an excellent manner

*The contour lines of the accompanying map are as given on the New Hampshire state geological atlas.

the schistose structure with quartz veins. A little farther northwest gneiss appears instead of schist. Here, then, there is a passage from slate through schist to gneiss.

Just west of Hollis Center is still another opportunity to observe an approach to the dividing line between the slate and the schist, though not so good as either of the two already described. Just west of Hollis Center there is slate. This grades through schist to the gneiss quarried at Proctor Hill.

Southeast of the slate area are several outcrops of gneiss: one at Shattuck's ledge in the northeastern part of the city of Nashua, another in the western part of the city, where it is quarried in one place, a third on the Nashua river, five miles above Nashua, a fourth at Flat Rock quarry, and again at Long Hill, south of the city.

The sudden transition from slate to gneiss close to the Nashua river will be referred to under the heading "Faults."

Eastward from Runnells' bridge, near Hollis, there is a gradation from the slate through schist to the gneiss at Flat Rock quarry, and a similar gradation from schist to gneiss between Nashua and Long Hill.

Thus southeast there is a gradation from slate through schist, schist with quartz seams to gneiss, similar to that from the slate area northwest.

Attempts to Harmonize Descriptions of Crosby and Hitchcock.—The above description of gradations in the character of the slate, schist and gneiss, suggests an explanation of an apparent lack of harmony between Crosby and Hitchcock. Crosby distinctly records gradation between the three rocks, and because of this gradation seems to call both the slate and the schist argillite, even though the argillite southeast of Nashua is exceedingly clear mica schist. Judging by the map, Hitchcock apparently recognizes the same gradation between the rocks, though I find no description in the text to confirm this inference, and calls both schist. I fear, however, that because of the schistose character of many of the slate outcrops, the area of slate has been entirely neglected.

Concerning Hitchcock's location of the gneiss area along the Nashua river, between Mine Falls and just south of the state line, there is a single area of probable gneiss on the river about four miles west of Nashua. This area is cut off on the southwest by slate just south of Runnells' bridge, and on the northeast by mica schist at Mine Falls. Hitchcock has overlooked

the gneiss east of Mine Falls, where two areas exist: one a mile west of Nashua (Main street) and south of the canal, where outcrops occur at a large quarry, and in the hill just west of the cemetery. The other area omitted is in the northeastern part of the city itself, at Shattuck's ledge, near the Merrimac river, a mile and a half from the outcrops just west of the city.

It is possible that these two areas should be classed as one, since no outcrops exist between the two areas to tell what the rock between them may be.

The line bounding Hitchcock's "Rockingham Mica Schist" seems to indicate the line between schist and gneiss, as if he did not recognize the slate as a separate rock from the schist. My northwestern line bounding the slate lies about parallel to his line bounding the Rockingham Mica Schist and a mile to the southeast of it.

Strike.—On the map accompanying this paper numerous dips and strikes may be found recorded. It now becomes necessary to observe their relation to determine what folds may exist in the area, for there are no strata within the slate area itself whose repetition can indicate the structure.

Within the slate area and in the gneiss along the northwestern boundary the strikes measured are much the same. North of Nashua there is slight evidence that the anticline there tends to form a nose; but all other variations from N. 33° E. are such

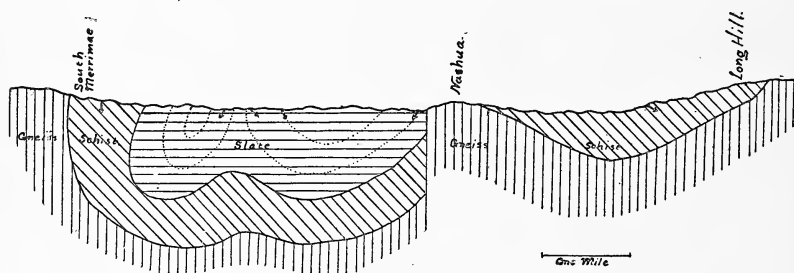
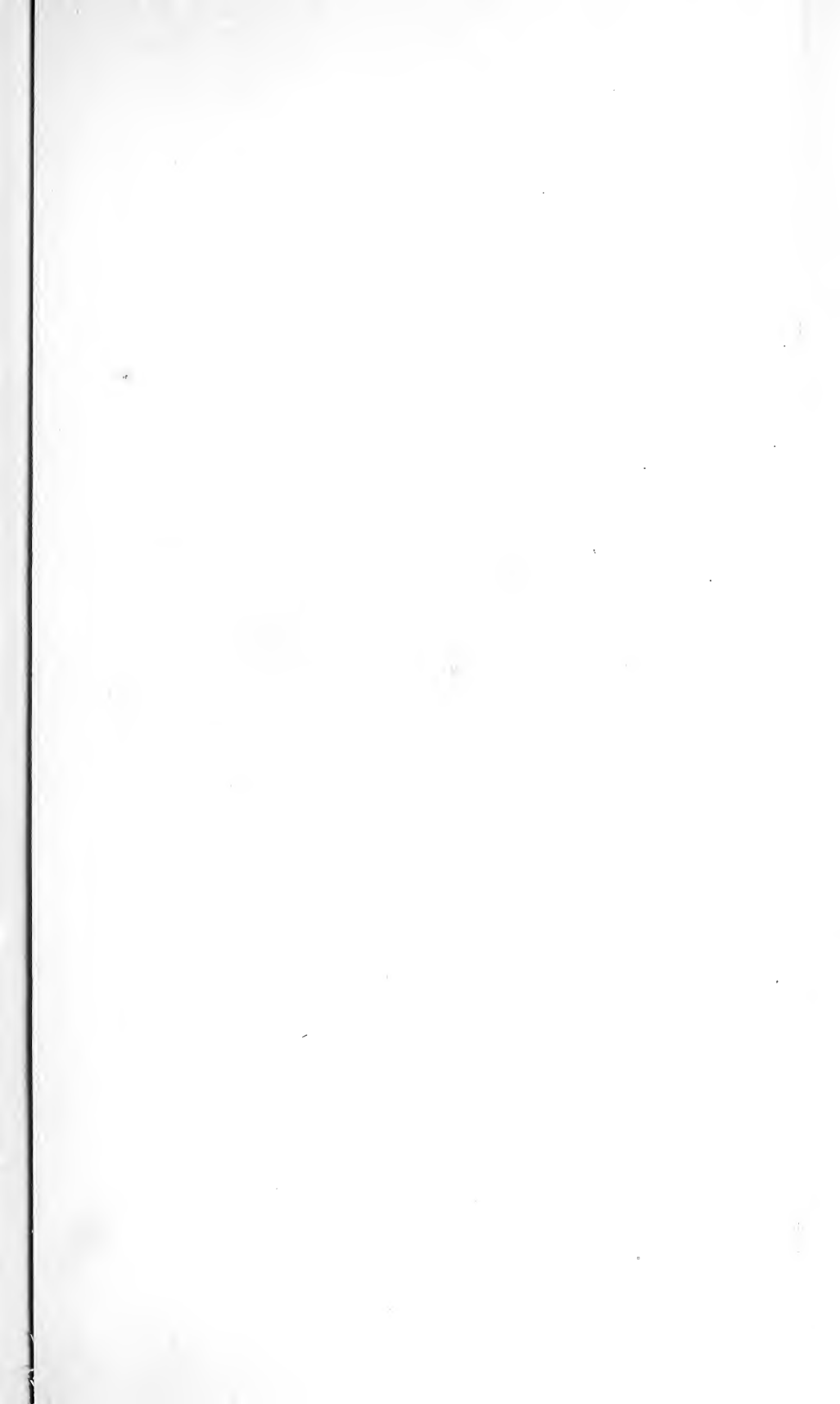
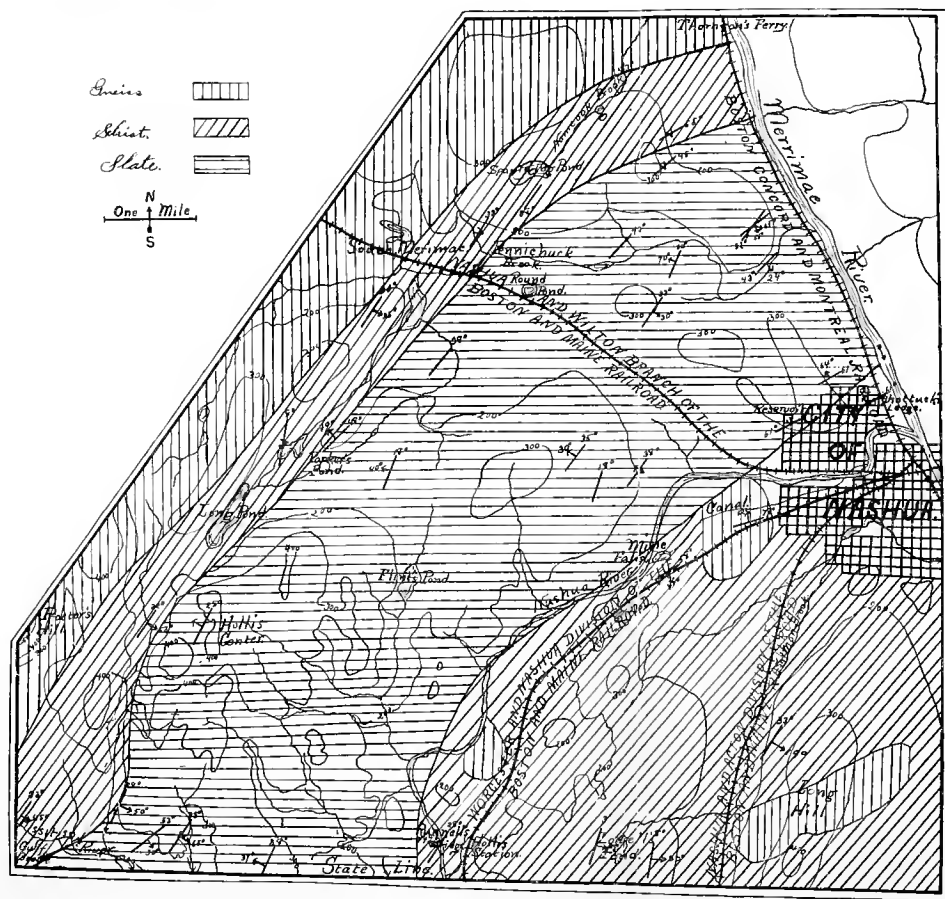


FIGURE 3. Section northwest-southeast across the area.

as a badly crushed area might represent; variations too small to be systematized even by minute observations at all points. This general similarity of strike indicates horizontal folds extending in the direction of the strike.

A study of the dip along lines at right angles to the strike reveals the anticline of a fold running in the direction of the strike along the western half of the slate, while a syncline runs along the eastern half. These are here represented in a diagram. (Fig. 3.)





Faults.—At the reservoir in Nashua are evidences of a fault; there is in the slate a seam of graphitic slate with veins of quartz near by. In this graphitic slate much crushing and slipping has occurred. The strata are on edge with strike N. 73° E.

The argument for a fault in this locality is sustained, in fact made necessary, by the structure of the region. The general succession of strata from southeast to northwest, is gneiss, schist, slate, schist, gneiss, with no evidence of unconformity; but at Shattuck's ledge the gneiss appears in close proximity to the slate, with little chance for schist between. The dip at Shattuck's ledge compared with the dip observed in the schist to the south indicates that the gneiss exposed at Nashua is in an anticline.

North of the gneiss at the quarry just west of Nashua a fault is possible, but not necessary to explain the structure, if schist not exposed underlies the river valley. While schist occurs at Mine Falls, schistose gneiss occurs two miles farther west with no schist that is exposed to the north, and beyond Runnells' bridge the eastern boundary of the slate area bends southeastward across the line of strike. Thus while the evidence of faulting is very marked near Nashua it becomes less marked southwestward.

Other evidences of faulting exist near the mouth of Gulf brook, and just west of Hollis Center. Along this line the presence of slickensides in graphitic slate, with quartz seams near by, indicate that a line connecting these two points is a line of faulting.

Cause of Metamorphism.—Finally, it remains to ascertain the cause of the metamorphism. This involves a petrographical problem, especially on the gneiss. There is no igneous rock to be found in the area, unless the gneiss itself be of igneous origin.

If the gneiss itself is not of igneous origin there may be igneous rock not far below, or not far beyond the margins of the area, though no locality of such minerals as are common where igneous material comes in contact with sedimentary material is here to be found, nor is there any evidence of intense heat.

Regional metamorphism affords a satisfactory explanation. The intense crumpling of the strata, the steep dip, the bands of quartz alternating with the slate along the margins of the gneiss, with lack of evidence of intense heat in the immediate vicinity, all indicate that the metamorphism is regional.

NOTES ON THE GEOLOGY OF THE BOSTON BASIN.

J. L. TILTON.

The region about Boston forms a basin. Standing on the reservoir at College Hill one looks north, west and south upon lines of hills surrounding Boston and the thickly populated adjoining country. In the relation of the rocks underlying the drifts this region also forms a basin. The distant hills are of hornblende granite extending from near Marblehead southwest to near south Natick, thence east toward Quincy. Close to this granite area are other igneous rocks, and within the basin, conglomerate and slate so related and concealed by drift as to present many difficult problems.

It is not surprising that the discussion* of the area contains not only a mass of conflicting conclusions, but even a mass of conflicting statements concerning field evidence. The rocks seemed to grade into one another; the felsite along the margin of the basin appeared where observed to penetrate the granite instead of the granite the felsite; the flow structure seemed stratification; the sedimentary material is so related to the igneous rock and presents plains of stratification so obscure and nearly vertical that to some the conglomerate appeared uppermost, to others the slate uppermost, while to still another there seemed to be two beds of conglomerate. For years it was agreed that the felsite, porphyry and diorite were all originally sediments changed to their present conditions by varying degrees of metamorphism.

In age the sedimentary rocks were variously classified, Cambrian, Devonian or Carboniferous.

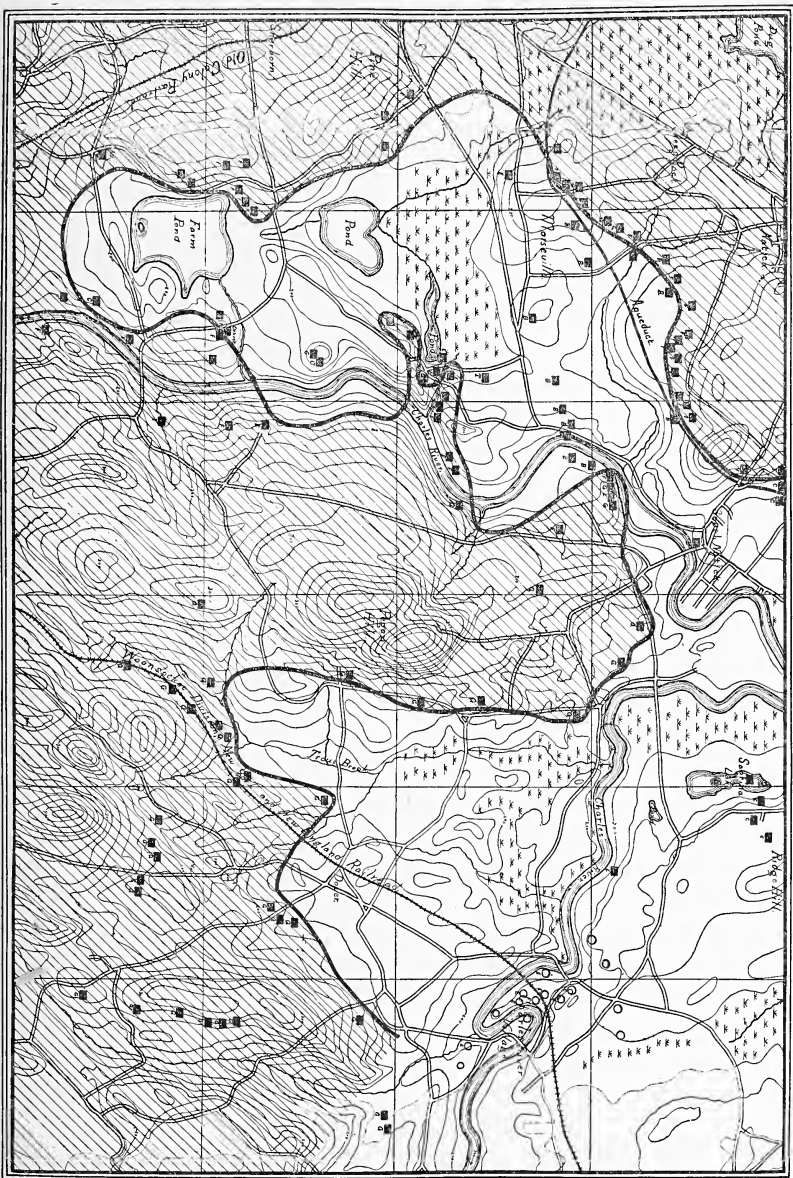
Since 1877, Dr. M. E. Wadsworth and Mr. J. S. Diller have given careful attention to these problems. In conclusion Mr. Diller,† after a presentation of evidence that seems incontro-

*The discussion is given in full in "The Azoic System," Whitney and Wadsworth, Bull. Mus. Comp. Zool. at Cambridge, Mass., Vol. VII.

† "Felsites and their Associated Rocks north of Boston," J. S. Diller, Bull. Mus. Comp. Zool. at Cambridge, Mass., Vol. VII.

THE SOUTHWESTERN PART OF THE BOSTON BASIN.

——— J. L. Allen, December, 1894. ———



Scale 1/16 inch = 1/2 mile.
 General Dip and Strike of Pressure Planes.
 Gneiss.
 Pluton.
 Felsite.
 Sill.
 Conglomerate.
 Breccia.
 Eruptive Rock.
 Position not determined.

vertible, based as it is on both detailed field evidence and microscopic examination of the rocks, states that in the area he studied the stratified rocks within the basin are the oldest rocks, the granites surrounding the basin are next in age, then come the diorite, diabase and melaphyre in order. He also concludes that the granites, felsites, diorite, diabase and melaphyre are all eruptive rocks, not derived by metamorphism from any part of the stratified rocks.

These conclusions relate to the part of the basin north of Boston where evidence is most abundant and complete. In the fall of 1894, it was the writer's privilege to study the southwestern part of this basin and to prepare the accompanying map, the plate of which is now kindly loaned by the Boston Society of Natural History. This map and the paper that originally accompanied it* give the location of outcrops to be found in the area under consideration and a discussion of the relation of those outcrops based in part on the field evidence and in part on the microscopical character of the rock. The basin itself was found to extend in narrow areas farther southwest than formerly supposed.

* "On the Southwestern Part of the Boston Basin," Proc. Boston Soc. Nat. Hist. Vol. XXVI, June 28, 1895.

NOTE ON THE NATURE OF CONE-IN-CONE.

BY CHARLES R. KEYES.

Cone-in-cone is a term which has been applied more or less widely to a peculiar structure often found in beds of shale. Ordinarily it appears in thin sheets or layers, from three to six inches in thickness. The bands have a more or less well-marked columnar structure, each column being about half an inch in diameter and composed of a series of small conical segments set one within another. In general appearance fragments resemble the familiar coral *Lithostrotion*.

Much has been written on the origin of cone-in-cone, and numerous and widely different explanations have been offered. So far as I know, none of these numberless attempts to account for this peculiar structure appear to be satisfactory expositions of the true cause of the formation.

Recently there have been obtained in Marion, Boone and Webster counties, in this state, some unusually instructive examples which offer, I believe, a correct solution to the problem of origin. These specimens range from a black, opaque, clayey variety—the common form—through all gradations to a white, translucent kind. The latter is found to be made up of numerous long, often needle-like crystals and flat plates which radiate from a center—the apex of the cone—new needles coming in as rapidly as the spaces between those near the center become large enough to admit them. Chemical analysis shows that this variety is nearly pure calcic carbonate, in a well crystalized form. Analysis of the more earthy kinds also show a high percentage of lime. The results of examinations by Prof. G. E. Patrick are as follows:

- | | |
|---|---------------------------------|
| I. Clear variety from Madrid... | 96.36 per cent Ca CO_3 |
| II. Clayey variety from Fort Dodge..... | 83.12 per cent Ca CO_3 |

As the clear cone-in-cone acquires more and more clayey matter the crystals of calcite gradually lose their mineralogical

characteristics until in the common form the presence of calcite would not be suspected, and the surface of the cones, instead of showing clearly the individual calcite needles sharply terminating, has only a peculiar crinkled or roughened appearance.

Owing to the very strong crystalizing force known to be possessed by calcite, so powerful an influence is exerted by this substance in solution, which is manifestly at the point of saturation, though distributed rather sparingly through the clay layers, that even the clay is pressed into the form assumed under normal conditions by the calcite. The process and results are not unlike those which have taken place in certain sandstone beds in central France, in which calcic carbonate has crystalized in the sand, and large perfect models of sand cemented by lime are found, having the well formed and characteristic crystallographic faces of calcite.

TWO REMARKABLE CEPHALOPODS FROM THE UPPER PALEOZOIC.

BY CHARLES R. KEYES.

There have been recently discovered in the coal measures of Mississippi basin some excellently preserved remains of Cephalopods, which are remarkable on account of the huge size attained. Both are representatives of the retrosiphonate Nautoidea; but one is a member of the most closely coiled end of the series, while the other is a perfectly straight form. The former belongs to the genus *Nautilus* and the latter to *Orthoceras*.

The first group comprises a series of shells, which were obtained from the upper coal measures at Kansas City, Mo. Several unusually fine specimens are the property of M. S. J. Hare of that place, and others are in the possession of other collectors. The form was originally described by White* as *Nautilus ponderosus*, the diagnosis of which is essentially as follows:

* U. S. Geol. Sur., Nebraska, p. 236, 1872.

Shell attaining a large size, subdiscoidal; umbilicus large, or nearly equaling the dorso-ventral diameter of the outer volution near the aperture; volutions three, enlarging their diameter more than three-fold each turn; all broader transversely than dorso-ventrally; inner ones slightly embracing, while the last one is apparently merely in contact with the others near the aperture; each broadly flattened or a little concave on the periphery, and (particularly the last one) somewhat flattened between the periphery and the middle of each side, from which point the sides are broadly rounded into the umbilicus, the greatest transverse diameter being near the middle; ventro-lateral or outer angles of the last whorl (in somewhat worn casts), each provided with obscure traces of about twenty wide, undefined nodes, scarcely perceptible to the eye; septa numerous, rather closely arranged, making a slight backward curve on each side, particularly between the middle and outer angles and crossing the broadly flattened dorsum with a strong backward curve; surface with distinct lines of growth, which curve strongly backward like the septa, in crossing the outer side.

White's specimen was not as perfect; the recently acquired material, and consequently the latter, is of unusual interest as elucidating structural points which were previously obscure. The large dimensions which the shell attained is quite remarkable, especially when taken in comparison with the other forms of the group known from the same geological formation. Rarely do any of the species of the genus from the Carboniferous of the region reach a diametric measurement of more than four or five inches. The specimens of *Nautilus ponderosus* recently found are twelve to fifteen inches in diameter and weigh upwards of fifty pounds.

The second group to which attention is called includes a huge *Orthoceras*—*O. fanslerensis*—from the lower coal measures at Fansler, Guthrie county, Iowa. It may be briefly described as follows:

Shell very large, thin, tapering very gradually; septa very thin, moderately concave, about two to the space of an inch near the large end; surface smooth. Diameter at larger extremity three inches, length probably not less than six feet.

It is a well known fact that the straight-shelled cephalopod was an abundant form of life during Paleozoic times. This is attested by the large number of species that have been described, those of the *Orthoceras* group alone numbering over 1,200. The culmination and greatest expansion of the group was in the Silurian, and from that period it appears to have gradually dwindled in number of species, size and abundance until at the close of the Paleozoic the form was all but extinct. In the American Silu-

rian some of the shells attained huge proportions, but with the general decline of the group the later ones have heretofore seemed to rapidly become dwarfed until only small, unimportant individuals were recorded after the Devonian. In the Carboniferous a few diminutive species have been described, most of them but a few inches in length. In the coal measures of the Mississippi basin the remains found were of rather rare occur-

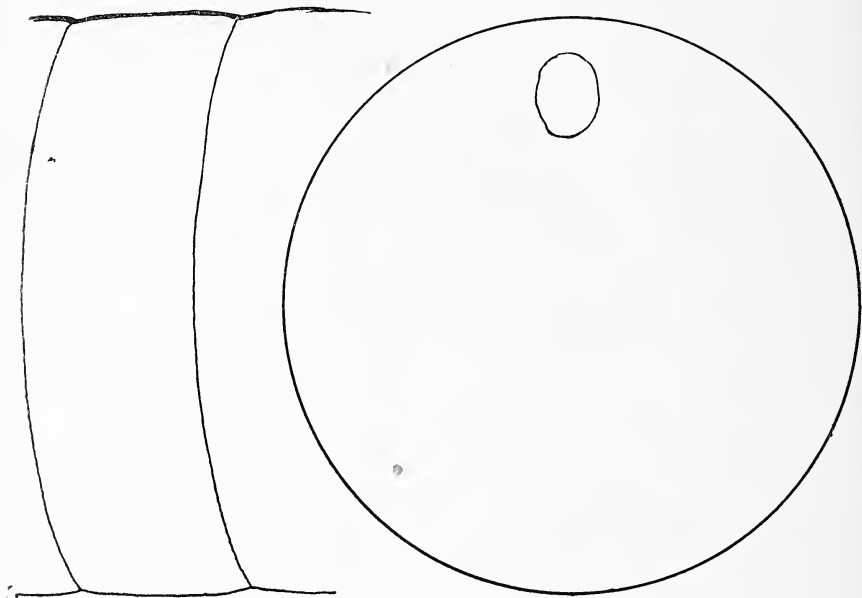


FIGURE 4. Section of *Orthoceras fanslerensis*.

rence, imperfectly preserved and of very small size. Seldom did the shells exceed six inches in length and half an inch in diameter.

Of late years, however, some unusually fine material has been obtained in the black shales of the lower coal measures in the vicinity of Des Moines, Iowa. Several of these shells were so large as to excite considerable wonderment. Some were over two feet long and one inch in diameter at the larger end. These were thought to be giants of their kind and day. But these are small, and all the other Carboniferous species are mere pigmies by the side of the recently found shell from the coal mines of Fansler. The species is *O. fanslerensis*, and the unique specimen here described was obtained by Mr. M. G. Thomas, state mine inspector.

VARIATION IN THE POSITION OF THE NODES ON
THE AXIAL SEGMENTS OF PYGIDIUM OF
A SPECIES OF ENCRINURUS.

BY WILLIAM HARMON NORTON.

In defining the different species of the genus encrinurus (Emmrich) use has frequently been made of the disposition of nodes on the rings of the mid-lobe of the tail-shield. It is largely by this diagnostic that Foerste, for example, distinguishes *E. thresheri* from *E. ornatus*. Hall and Whitfield* and the latter authors again, use the same criterion in separating *E. ornatus* from the European species figured in Murchison's Siluria.†

This has been the perhaps unavoidable result of the scarcity of materials at hand. Several species of this genus have been described, each from a single pygidium. The specific importance of this feature having thus been exaggerated, any variation in it is of paleontological as well as evolutionary interest, and will be of value in the long-needed revision of the genus.

The specimens which afford the facts I am about to present were taken some years since by Prof. A. Collins, Sc.P., of Cornell College, and the author, from a single stratum near the top of Platner & Kirby's quarry, Mount Vernon, Iowa. They were associated with a rich fauna, but unfortunately the fossiliferous area was so limited that, though the quarry has been largely extended, scarcely a fossil has since rewarded the search of the collector. The investigation is therefore simplified by the absence of such factors as would obtain if the specimens had been taken from widely separated localities, or from a considerable vertical range.

Coming from a station near the summit of the Anamosa beds, which lie above the Le Claire, the position of the species is perhaps higher than that of any other American Encrinurus.

* The Clinton Group of Ohio, Part II, pp. 101, 102, A. E. Foerste. Bulletin of The Laboratories of Denison University, II.

† Report Geological Survey of Ohio. Vol. II, pp. 155, 156.

The species in question which is of the general type of *Encrinurus punctatus* Wahlenburg, is well represented in the collections by two perfect, or nearly perfect, specimens and by scores of cephalons, moveable cheeks and pygidia, occurring both as external moulds and internal casts.

The nearness of the fossiliferous stratum to the top of the quarry brought it well within the zone of weathering. The laminae of the rock were parted and the fossils thus disengaged with a single stroke of the hammer, and without any picking and cleaning that might mingle artificial with the delicate natural markings. The latter are exceptionally well preserved. To speak of the pygidia only, the caudal spine is shown in several specimens, the ninth pair of pleural are usually distinct, and even a tenth pair may sometimes be seen as minute ridges nearly aligned with the axial lobe and ending upon it in a tubercle. Of the segmental lines on the mid-lobe as many as thirty-one have been counted with the aid of a magnifying glass, and in seven specimens over twenty-five are thus visible, and in several specimens eight and even nine axial nodes have been observed.

The investigation has thus been specially favored in the number and perfection of the specimens at hand. The prominence also of the large rounded anterior tubercle affords a sure ground which would be lacking if the investigation were carried over to the less distinct tubercles on the broad pleural annulations. In the same way the size of the specimens is of advantage. The largest twenty-three mm. in length and width, slightly exceeds in these dimensions the largest *Encrinurus* the author has seen figured or described. From this size the specimens range to a minimum of eight mm. in length and breadth. In several of the smaller pygidia, the axial lobe is slightly more convex and the central longitudinal space between the discontinuous segments is more or less obscure. The first nine segments in especial, are plainly continuous. While it is not thought that these are specifically distinct, they are separated in the following table by being marked with a star. Excluding these and considering the remainder whose specific identity can not be questioned, the following variation is observed:

No. of Nodes.	AXIAL SEGMENTS OCCUPIED.									
1.	1st.	2d.	(?)	3d.						
2.	3d.	4th.	5th.	6th.						
3.	7th.	8th.	9th.	10th.						
4.	10th.	11th.	12th.	13th.	14th.					
5.	14th.	15th.	16th.	17th.	18th.	(?)	19th.			

The following table sets forth the facts observed graphically and in detail. It will be noted that not a single segmental line of the first twenty-three is unoccupied by a tubercle. No law obtains as to the successive number of the intervening segments. For comparison the sequences of nodes on two described species are inserted. Of the distinct trends observable in the grouping of the nodes that toward the formula of *E. ornatus* is most largely represented in the specimens at hand.

Geological Laboratory, Cornell College, December 31, 1895.

NUMBER OF AXIAL ANNULATIONS.

NO. OF SPECIMEN.	NUMBER OF AXIAL ANNULATIONS.																							
	1st.	2d.	3d.	4th.	5th.	6th.	7th.	8th.	9th.	10th.	11th.	12th.	13th.	14th.	15th.	16th.	17th.	18th.	19th.	20th.	21st.	22d.	23d.	24th.
1.					0				0				0				0							
2.		0			0				0				0					0						
3.		0			0				0				0				0							
4.		0			0				0				0				0					0		
5.		0			0				0				0				0							
6.		0			0				0				0				0							
7.		0			0				0				0				0							
8.		0			0				0				0				0			0				
9.		0			0				0				0				0							
10.		0			0				0				0				0							
11.		0			0				0				0				0							
12.		0			0				0				0				0			0				
13.		0			0			0				0				0				0				
14.		0			0			0				0				0				0				
15.		0			0			0				0				0				0				
16.		0			0			0				0				0				0				
*17.		0			0			0				0				0				0				
18.		0			0			0				0				0				0				
19.		0			0			0				0				0				0				
20.		0			0			0				0				0				0				
21.		0			0			0				0				0				0				
22.		0			0			0				0				0				0				
23.		0			0			0				0				0				0				
24.		0			0			0				0				0				0				
25.		0			0			0				0				0				0				
+26.		0			0			0				0				0				0				
27.		0			0			0				0				0				0				
28.		0			0			0				0				0				0				
29.		0			0			0				0				0				0				
30.	0				0			0				0				0				0				
*31.	0				0			0				0				0				0				
32.		0			0			0				0				0				0				
33.		0			0			0				0				0				0				
34.		0			0			0				0				0				0				
35.	?	0			0			0				0				0				0				
36.	0				0			0				0				0				0				
37.	0				0			0				0				0				0				
38.					0			0				0				0				0				
39.					0			0				0				0				0				
40.					0			0				0				0				0				
41.					0			0				0				0				0				
42.					0			0				0				0				0				
43.					0			0				0				0				0				

*No. 17. *E. ornatus*, H. & W.

+No. 26. *E. punctatus*, Murch. *S. luria*. Pl. III, fig. 6

#No. 31. *E. thresheri*, Foerste.

A THEORY OF THE LOESS.

B. SHIMEK.

Some years ago in an article entitled "The Loess and Its Fossils,"¹ the writer advanced certain opinions the modification of which seems to be called for by subsequent investigation and thought.

In that paper it was shown, principally from a study of the fossils, that the theory of the lacustrine origin of the loess, held with very few exceptions by American writers,² is untenable, and that the origin of the loess in violent fluvial floods, also sometimes suggested, is equally improbable, and the theory was there offered that the deposit was formed in ponds and lakes similar to those which were formerly abundant in northern Iowa, and by quiet overflows of the sluggish prairie streams.

Although it is extremely probable that certain limited portions of the unmodified loess were deposited in this manner, the theory does not account for the most extensive deposits which usually cap the highest hills, especially along our streams which so often seem to cut their channels through the highest ridges. This difficulty led the writer to further investigation, which led to the conclusion that wind was the prime agency concerned in the formation of these deposits, and that Richthofen's theory of the formation of the Chinese loess, tempered and modified in important particulars, will account for all the phenomena of the loess of the Mississippi valley.

That the loess is not of aquatic origin is indicated by the following facts:

¹*Bull. Nat. Hist. S. U. I.*, Vol. II, pp. 93-98.

²Prof. Calvin, in *Iowa Geol. Survey*, Vol. IV, p. 84, recently suggested the aeolian origin of a part of the loess in Allamakee county.

First.—The land area during the period of the formation of the loess was large as is shown by the remains of great numbers of terrestrial molluscs.³

Not only the number of species but the number of individuals of the terrestrial forms is much greater, a fact especially significant since the pond molluscs are all very prolific and had the conditions been favorable to their development much greater numbers of the fossils should occur.

That the shells of the loess were deposited *in situ* and were not carried any great distance by water has already been pointed out by the writer.⁴

Second.—The occurrence of dry region molluscs, such as *Succinea lineata*, *Pupa atticola*, *Patula cooperi*, etc., has also been pointed out.⁵ The great majority of the remaining species occur now in a living state throughout Iowa and eastern Nebraska, more particularly in wooded regions. Most of them do not seem to require an excess of moisture, but thrive under present conditions.

Third.—The deposits often occur so high above the surrounding region that it is difficult to conceive of the manner in which water laden with the fine silt could reach the places of deposition.

Fourth.—The siliceous and other particles which the loess contains are generally angular and often show a freshness of fractures which would scarcely appear in particles which had been rolled and washed about by the waters.⁶

Fifth.—The distribution of the loess is better accounted for by the consideration of the action of winds, and by the distribution of the forest areas, as will be shown in the following pages.

The fact that stratification and lamination sometimes appear in the loess, showing the action of water, together with the presence of aquatic molluscs, can also be accounted for under the wind theory; for, as now, so at the time that the deposits were being formed, ponds and lakes of various sizes were scattered over the state, and much of the dust carried out in clouds over these bodies of water would have been deposited in them.

³See *Bull. Nat. Hist. State Univ. Iowa*, Vol. I. p. 209, *et seq.* *Succinea verilli* and *Pupa decora* should be stricken from the list, and *Pupa holzingeri* Sterki should be added. This species is rather rare in the loess of Nebraska, but in the living state it is quite common in both Iowa and eastern Nebraska.

⁴*Bull. Nat. Hist. S. U. I.* Vol. II, pp. 95 and 96.

⁵*Ibid.* p. 93.

⁶See also Prof. R. D. Salisbury's report in *Ark. Geol. Survey*, Vol. II, pp. 225, 226.

That such bodies of water existed, though, as before stated, not of the extent required by the lacustrine theory, is also shown by the distribution of the pond mollusca, which are found in bands or layers similar to those which may be observed on the edges of our small ponds to-day. These layers are usually of but slight vertical extent, showing that the ponds did not persist during the entire period of deposition of the loess, but, like the ponds of to-day, were subject to changes. But if the water area was not great, comparatively little of the material carried by the winds could be deposited in this manner, and as a matter of fact we find comparatively little loess which shows such origin.

Secondary loess, which had been subsequently eroded and re-deposited on lower lands by running waters, and which usually shows stratification, should not, of course, be considered in this connection.

In the consideration of any theory of the mode of deposition of the loess, two propositions, which seem to be capable of satisfactory demonstration, should be borne in mind, namely, that the loess was deposited under climatic conditions essentially the same as those which prevail in the same region to-day; and that the deposition was slow and continued through a period of considerable extent.

That the first of these propositions is true is shown by the molluscs which furnish the most satisfactory evidence of the character of the conditions supporting life during that period. The same species, with but very few exceptions, which occur in the loess, exist in abundance now throughout the region under consideration, the distribution of the fossils being exactly such as may be observed under present conditions. If, for instance, we compare the modern molluscan fauna of eastern Iowa with that of eastern Nebraska, we find certain differences which are almost exactly duplicated in the loess faunas of the two regions.⁷

For instance, *Succinea lineata* W. G. B., the common succinea of eastern Nebraska, is also the most common succinea of the loess of that region, whereas *Succinea avara* Say, the most common succinea of eastern Iowa, is also the most common species of the genus in the loess of the same region.

The majority of our species show a like distribution,⁸ plainly

⁷ No reference is here made to the Lamellibranch and Prosobranch fluviatile faunas, which seem to have spread into the region in question from their center of distribution in the southeast comparatively recently.

⁸ The loess fossils of Europe are likewise like the modern forms inhabiting the same region.

indicating conditions not essentially different from those which now prevail.⁹

Additional weight attaches to the evidence of these molluscs when we consider that they are in themselves witnesses to an abundant flora of the period, for with scarcely an exception they are purely herbivorous, and frequent places in which shade, protection and food are furnished by abundant plants.

The presence of a vigorous vegetation is further attested by the leaching of peroxide of iron from the loess soil and its deposition in tubules and concretions.¹⁰

That the amount of moisture was not excessive has already been pointed out. The great preponderance of terrestrial molluscs, at least some of them, now capable of living and multiplying in regions even drier than that under consideration, and the majority of them living abundantly in our state to-day, is certainly significant.

But even if we grant that the average temperature was somewhat lower than at present, and the amount of moisture somewhat greater—conditions by no means essential to the phenomena of the loess—it cannot be questioned that the climate of the loess was sufficiently mild to support an abundant fauna and flora from the very beginning of the formation of these deposits. Glacial conditions certainly no longer existed, for sufficient time must have elapsed after the recession of the glaciers to clothe these prairies with verdure, for the mollusc remains are found in the lowermost portions of the deposits and the favorable conditions necessary for their development must have existed from the very beginning. The prevailing conditions being then essentially the same as now, and the topography of the continent being essential as we find it to-day, it seems fair to assume that the prevailing strong winds were, as now, northwesterly. This point will again be emphasized.

The truth of the second proposition that the loess was deposited slowly is supported by the following facts:

⁹The writer formerly leaned toward the conclusion, drawn by McGee and Call in a paper on the loess of Des Moines, that the occurrence of depauperate forms was proof of a much colder climate than now prevails, but he has since found recent forms of several of the species common in the loess which exhibit great variation under different conditions even in the same locality. For example, shells of living *Mesodon multilinata* Say, from different points in the immediate vicinity of Iowa City, vary from 15 to 26 mm. in greater diameter, while fossils of the same species from the same region now in the writer's possession vary from 12 to 23 mm. This variation seems to be purely local and cannot be assigned to general climatic conditions. This was suggested in the writer's paper to which reference has already been made, p. 93, footnote 2.

¹⁰See *Le Conte's Geology* pp. 136, 137

First.—The vertical distribution of the molluscs. The writer has already shown¹¹ that these molluscs were most probably deposited *in situ*, and sufficient time must have elapsed at least for the production and development of the successive generations.

Second.—The fineness and homogeneity of the loess material. This is of importance, for had the deposits been made quickly by powerful concentrated agencies, whether wind or water, much more coarse material would have been mingled with the fine debris.

Third.—No plant remains of undoubted loess origin occur. As the plants undoubtedly existed during the entire period the deposition must have gone on so slowly that ample time was given the plant remains to crumble in decay and mingle with the soil.

With these propositions as an aid let us consider the following conception of the formation of the loess deposits:

The region formerly covered by the glaciers remained a vast drift-covered plain after the recession of the glaciers.

No loess was to be found, but the surface material consisted of unassorted drift, here and there heaped up in ridges and moraines. Streams soon cut their way through this material¹² and ponds more or less numerous remained in the depressions of the plain.

The climatic conditions having so improved, plants, at first the smaller forms, spread over the plain, and soon trees, in whose shades numerous molluscs lived and prospered, appeared in narrow lines along the streams, the surface conditions being not unlike those of the northwestern portions of the state to-day. Forests gradually spread over portions of the area, principally along the river-valleys and on hillsides in the manner pointed out by Prof. Macbride.¹³

When vegetation, especially the forests, had gained a foothold, then commenced the deposition of the loess.

¹¹*Bull. Nat. Hist. S. U. I.*, Vol. II, p. 95.

¹²If it be true that our streams generally follow the highest ridges of the drift, even without reference to the loess, i. e. if the streams run in *glacial* ridges (and the writer knows of some cases where this is true), then the fact can be accounted for by the theory offered in the paper by McGee and Call already cited, pp. 22-23, but the theory fails when applied to the loess because of the climatic conditions required.

¹³See paper: *Forest Distribution in Iowa and its Significance*, in this volume.

It is but fair to say that the theories thus presented by Professor Macbride and the writer, while leading to the same results, were developed from different standpoints along entirely independent lines of investigation.

The strong northwesterly winds blowing over the prairies, which during a part of the year at least were quite dry, gathered up clouds of sand and dust. The coarser material was blown and rolled about on the surface, the constant grinding furnishing renewed supplies of finer material, while this finer material was carried higher, being finally swept over the forests, and there deposited.¹⁴

That this is not a fanciful view of the work actually performed by winds has been nicely demonstrated in eastern Iowa during the past two years. High winds prevailed during considerable portions of both years, the dry spring of 1895 being particularly remarkable in this respect, and observations upon the material so transported were made in Johnson county. In the northern prairie portion of the county, beyond Solon, fine sand was heaped up in open places, in some cases to a depth of over a foot, within twenty-four hours, while fine dust only was carried into adjacent groves, and was there deposited upon every available surface to a depth of not less than one mm. The writer's observations of the effect of the winds which so prevail in Nebraska also confirm this.

That this fine material now constituting the loess, was so deposited in forests is further shown by its distribution. That the loess and the original forest area in eastern Iowa almost exactly coincide is a well established fact, which has been demonstrated beyond question by McGee.¹⁵

The forests are found along the streams, and also principally on the southern and eastern slopes of the hills, and the loess is found in exactly the same situations.

Indeed it has often been suggested that there is something peculiar to the loess which renders it favorable to the development of the forests—whereas the fact seems to be that the forest is especially favorable to the deposition of the loess if lying adjacent to or near drift-covered plains.

That the forest could have preceded the loess is shown by the fact that scrub growths of bur oaks have been able to gain a foothold along the shores of some of our northern (Iowa) lakes and streams in a purely glacial soil, thus forming the nucleus of a forest in comparatively recent time, while in the same region in groves evidently somewhat older a thin layer

¹⁴ Interesting observations were made in 1894 by F. H. King (see *Eleventh An. Rep. of the Wisconsin Agr. Ex. Sta.*, p. 292 *et seq.*) upon the effect of winds on vegetation in drifting soil which bear out the conclusions presented in this paper.

¹⁵U. S. Geol. Sur., 11th Ann. Rep., Part I, pp. 296, *et seq.*

only of loess-like soil is found.¹⁶ Quite important too is the argument furnished by the physical properties of the loess material. This in eastern Iowa is always very easily eroded, so much so that upon cleared hillsides it is often impossible even for bluegrass to gain a foothold, and failure has been the universal result of all attempts to cultivate such slopes. This being the case it seems hardly probable that trees, which require more time to become established than do smaller plants, could have gained a foothold upon these unstable hill-tops had they been formed. The organic matter which undoubtedly accumulated in these forests gradually decayed, mingled with the alluvium brought by the winds, and was finally consumed in leaching iron oxides from the lower strata of deposit.

Other, smaller, vegetation no doubt effected the deposition of fine alluvium in the same manner, but to a lesser degree, and by the aid of this probably were formed the thin layers of loess which sometimes occur in prairie country.

The element of time still remains to be considered. Without an attempt at exact computations, attention is simply called to the fact that in eastern Iowa the loess in no place exceeds fifty feet in thickness, the average being probably about ten or twelve feet, and that if we assume, for example, the deposition of a minimum of one mm. a year, the time required for the formation of the entire deposit would not be unreasonably great.

The deposition of loess material is no doubt going on in this manner to-day, and the investigation of this phase of the subject is worthy the attention of the most careful observers. The foregoing statements apply particularly to the loess of eastern Iowa. In the western part of the state and in eastern Nebraska much thicker deposits occur, which differ in many respects from the loess of eastern Iowa.

The western loess is thicker, coarser, with more siliceous material, and the writer has found it more frequently inter-laminated with sand. That it is much less easily eroded because of this difference in composition is a well known fact.

From the general topographical and climatic relations which exist between the eastern and western regions to day, it is probable that during the loess period, as now, the western region was drier (a fact also attested by the rather greater abundance of dry-region molluscs in its loess), and that strong winds were

¹⁶A further investigation of the soils in prairie groves of this kind is contemplated during the coming summer.

of more frequent occurrence than in the eastern region. The stronger winds and drier climate would coöperate in effecting the transportation of larger quantities of alluvium, which would also be somewhat coarser and more siliceous. The frequent interlamination of sand with the loess can be accounted for by more violent storm-periods.

The writer has seen such alternating deposits of sand and loess in Cuming county, Nebraska, near the margin of the Sand Hill country, which clearly show wind-action.

Much could also be written of the changes which probably took place after the deposition of many of the beds of loess, of the denudation of some of the hills, the modifications of the deposits by erosion, and kindred subjects, the discussion of which in connection with this question would be legitimate and desirable, but this would extend this paper beyond reasonable limits, and is therefore postponed.

The consideration of the facts herein briefly presented leads, then, to the conclusion that the loess is of æolian origin, and that it was deposited principally in forests and to a lesser extent in dense growths of smaller plants, while proportionately small quantities only were carried directly into the waters and there deposited.

PERFECT FLOWERS OF *SALIX AMYGDALOIDES* ANDS.

B. SHIMEK.

A native specimen of *Salix amygdaloides* Ands. growing in Iowa City, produces peculiar flowers which seem to be worthy of mention.

Whereas all *Salicaceae* habitually produce dioecious flowers, this specimen has, for at least three successive seasons, borne flowers most of which are perfect.

The accompanying figures will give a clearer idea of these peculiar flowers.

The hairy bract is shown at the extreme left; next to this is the narrow dark honey-gland (there are really three such glands in line in each flower) here occupying an unusual position, as in willows the honey-gland is normally in the axil of the pedi-

cel, and not between it and the bract as in this case; next are the stamens, being three in number, in all the flowers which were examined, but varying in position, some being on the receptacle, and others on the ovary; to the extreme right is the peculiar pistil which, instead of having a one-celled ovary, with



Fig. 1



Fig. 2.

FIGURE 5. 1 entire perfect flower; 2 cross-section of ovary.

two parietal placentae as in normal willows, usually has a two-celled ovary, one of the cells being nearly normal with two placentae, while the other is larger and shows four placentae, two of them consolidated, as shown in figure 2 which represents a cross-section of the ovary. These figures represent a fair average example of the perfect flowers, but considerable variation was observed. Some catkins consisted of staminate flowers wholly, being normal with five stamens. Other catkins had perfect flowers in part only, these being either apical, basal, or scattered, while still others had all the flowers perfect. A few pistillate flowers were also found.

The stamens in the perfect flowers vary much in length, all being shorter however than those of the truly staminate flowers, and they also show much variation in the development of the anthers, some being evidently abortive.

The perfect flowers produce seed, but whether this is capable of germination was not demonstrated.

COUNTY PARKS.

BY T. H. MACBRIDE.

The title of this paper would seem to require little definition. By county parks are meant simply open grounds available for public use in rural districts, as are city parks in towns. There is nothing new in the idea; it is simply an effort to call back into public favor the once familiar public "common." This does not, however, refer simply to public land such as government land, to be claimed and plundered by the first comer, nor, indeed, to land to be used by the public indiscriminately at all, but to land devoted to public enjoyment, purely to the public happiness, a holiday ground for country- and city-folk alike.

The general features which should characterize such public play-ground as is here discussed will also quickly suggest themselves to any one who chooses at all to consider the matter. In the first place the county park should be wooded, that it may afford suitable shade and shelter for those who frequent it; it should be well watered to meet other patent needs; it should be romantic, in order by its attractiveness to be as far as possible efficient. Above all it must be under wise control, be at all times suitably warded and kept, that its utility be transmitted from generation to generation. All this is plain enough and will be disputed by nobody. It is my purpose here to show that such parks are needed, that they are needed now, that they should have the highest scientific value, and that in Iowa they are everywhere practicable.

The necessity for such parks in Iowa seems to me to be threefold:

First.—As directly affecting public health and happiness.

Second.—For proper education.

Third.—To preserve to other times and men something of primeval nature.

Let us consider these points briefly in the order named

All of us in one way or another know something of the monotonous grind which makes up the life-long experience of by far the larger number of our fellow men. On the farm, in the shop, in the mine, day after day, one unceasing round of toil, into which the idea of pleasure or freshness never enters. How many thousands of our fellow men, tens of thousands of our women see nothing but the revolving steps of labor's treadmill, day in, day out, winter and summer, year after year, for the whole span of mortal life. This is especially so here, in these western states, where the highest ideal is industry, the highest accomplishment, speed. Our rural population is wearing itself out in an effort to wear out "labor-saving machinery." If you do not believe it take a journey across the country, anywhere through Iowa, and see how our people are actually living. They know no law but labor; their only recreation is their toil. Now, it is needless to say how abnormal all this is. We are as a people entrapped in our machines, and are by them ground to powder. The effect of it is apparent already in the public health, and will be the most startling factor in the tables studied by the man of science in the generations following. Not to paint too darkly the picture, attention may be called to the fact that rural suicides are not uncommon, and that the wives of farmers are a conspicuous element in the population of some of our public institutions. There must be something done to remedy all this, to preserve for our people their physical and mental health, and to this end, as all experience shows, there is nothing so good as direct contact with nature, the contemplation of her processes, the enjoyment of her peaceful splendor. If in every county, or even in every township, there were public grounds to which our people might resort in numbers during all the summer season, a great step would be taken, as it seems to me, for the perpetuation, not to say restoration, of the public health. We are proud to call ourselves the children of "hardy pioneers," but much of the hardiness of those pioneers was due to the fact that they spent much of their time, women, children and all, out of doors. All the land was a vast park, in which that first generation roamed and reveled. They breathed the air of the forest, they drank the water of springs, they ate the fruit of the hillsides while plum thickets were their orchards, and all accounts go to show that hardier, healthier or happier people never lived. Such conditions can never come again, but we may yet, by public grounds for common enjoyment, realize somewhat of the old advantage.

Again, such parks as are here discussed are an educational necessity. Our people as a whole suffer almost as much on the esthetic side of life as on that which is more strictly sanitary. How few of our land-owners, for instance, have any idea of groves or lawns as desirable features of their holdings. If in any community a farm occurs on which a few acres are given over to beauty the fact is a matter for comment for miles in either direction. A county park well-kept and cared for would be a perpetual object lesson to the whole community, would show how the rocky knoll or deep ravine on one's own eighty-acre farm, might be made attractive, until presently, instead of the angular maple groves with which our esthetic sense now vainly seeks appeasement, we should have a country rich in groves conformable to nature's rules of landscape gardening if not to nature's planting.

I am aware that at the first the right appreciation of a public park might be meagre. The first instinct might be to use the park as a convenient source whence to draw one's winter fire-wood, or as a free cow-pasture for the adjoining farmer, but such abuse would soon be rectified when the better idea of public ownership came to be understood. This leads also to the remark that such parks in Iowa are to-day absolutely needed to teach our people the first lessons in forestry; to advise them how and when to cut timber; the economic value of different kinds of trees and the value of woodland as such; the kind of soil which should be left to trees and such as may be profitably given over to tillage. We are soon as a people to be sent all to school in matters of forestry and arboriculture; sent to learn the value of the forest in the dear school of experience where we are to be taught the arithmetic of cost.

In the third place county parks would tend to preserve to those who come after us something of the primitive beauty of this part of the world, as such beauty stood revealed in its original flora. I esteem this from the standpoint of science, and, indeed, from the standpoint of intellectual progress, a matter of extreme importance. Who can estimate the intellectual stimulus the world receives by the effort made to appreciate and understand the varied wealth of nature's living forms? In this direction who can estimate how great has been our own advantage as occupants of this new world? But such is the aggressive energy of our people, such their ambition to use profitably every foot of virgin soil that, unless somewhere

public reserves be constituted, our so-called civilization will soon have obliterated forever our natural wealth and left us to the investigation of introduced species only, and these but few in number. It is a fact lamented, grievously lamented by all intelligent men, that in all the older portions of the country species of plants once common, to say nothing of animals, are now extinct. County parks, if organized soon, would enable us to preserve many of these in the localities where originally found.

The objection to all this is that such parks as here broached are impracticable. Such objection can lie in two directions only: (1) The lack of suitable sites, and (2) the lack of suitable control. As to the first, it may be said that in a great number of our counties, especially eastward, such sites exist and have, in many cases, been long used and, I am sorry to say, abused by our people:

“The Caves,” in Jackson county;

“The Backbone,” in Delaware county;

“Wild Cat Den,” in Muscatine county;

“Gray’s Ford,” in Cedar county;

“Pinney’s Spring,” in Allamakee county.

“The Palisades” in Cedar and Johnson counties, may be cited as illustrations both of the fact that sites exist and that people need and appreciate them. The “Backbone,” in Delaware, is ideal. Here are cliffs and rocks, woods, rivers and bountiful springs and, what is rare in Iowa, clusters of native pine. Hundreds of people visit the locality every year, and hundreds more would do so were the roads leading to the park in more passable condition, and especially were the grounds a park properly managed and controlled instead of, as now, a cow pasture, so stocked as to jeopardize everything green it contains. The “Den” in Muscatine county might be referred to in the same way. I believe it is not yet too late to find in possibly three-fourths of our Iowa counties, suitable sites, grounds, for the purpose contemplated in this argument.

The second count in the way of objection is a real difficulty whose gravity I do not for a moment attempt to minimize. How to secure, own and care for several hundred, or for that matter, several thousand acres of land to be used by all the people is a problem, especially under our form of government. Were we in the old world we should find no difficulty. Such localities are owned by the king or his equivalent and are

cared for and guarded with the same assiduity as any other private property. Nevertheless the people have free use of the most splendid parks and beautiful woods in the world. The same thing can be true of the United States, of Iowa, hopeless as the task may now seem. In the eastern states a movement to this end is even now discernible.

What Mr. Vanderbilt is doing in North Carolina, at Biltmore, will doubtless be done presently in all our mountainous and forested states. This is another opportunity for our millionaires, and forest foundations properly established will prove for future generations rich in benediction as any university endowment left in the name of whatsoever state or sect. In Massachusetts five years since a movement was inaugurated for the accomplishment of similar purposes in New England. A board of trustees, by legislature authorized to act, becomes the legatee of suitable property donated for public use, becomes the curators of such grounds and the custodians of funds bequeathed for the care of such lands or for their purchase. The results in Massachusetts of just a simple effort have in five years proved most gratifying to the projectors, as to every lover of his native land. Thousands of acres have already been rescued from spoliation and subjected to intelligent management, such as will eventually result in the attainment of all the beneficent ends for which public parks exist. In Iowa nothing is done; nothing will be done until somebody or some association of our citizens makes a beginning. That the effort will one day be made there is no doubt. Whether it shall be made in time to save that which nature in this direction has already committed to our hands is a question. Is not the problem worthy the consideration of the Iowa citizen and legislator, and does it not open to us a field where by practical activity we may again show before the world our practical sense and wisdom?

NOTES ON FOREST DISTRIBUTION IN IOWA.

BY T. H. MACBRIDE.

The peculiar character of our American forest geography early attracted the attention of intelligent observers. Civilized men, Frenchmen, crossing the continent from the Atlantic seaboard, after threading for two hundred leagues a forest almost unbroken, suddenly found themselves in the presence of vast treeless plains, extending westward across a large portion of the central Mississippi valley. In wonder and admiration the *voyageur* looked upon these great plains, grass-grown and flower-bedecked, and found them counterpart to the green meadows of France; to them he gave the name prairie, a word now so familiar as to have long lost for all English-speaking men every vestige of foreign origin. How these great meadows ever came to exist or persist in the region where they first were seen, or why the forests of the east should so suddenly stop was a problem the *voyageur* could not solve, and has been a problem from the days of the *voyageur* until now.

In these times of almost universal forest extermination, when we are in sight of the era in which Americans must laboriously undertake the work of re-forestation, it is well that we should closely attend to conditions once established by nature, that we may hereafter act with her assistance, for in plant distribution, whatever our blunders may be or have been, nature we may be sure has seldom made a mistake.

In general, two factors are said to control forest distribution on the planet; the one, rainfall, the other, temperature. If the rainfall is deficient there can be no forest, rainfall seems never to be excessive, and if a region is too cold there is no forest. In proof of this we have but to look at the high altitudes and latitudes of the earth. What makes our Iowa problem therefore peculiar, is the fact that forest distribution here, as elsewhere in prairie regions, does not accord with these general

principles. Our country is not too cold, neither is it too dry; the rainfall in eastern Iowa being almost, if not quite as great as in Indiana, where the primeval forest was once heaviest. Indeed the uniformity of general conditions raises the problem: there seems to be nothing to hinder, therefore why is not the forest universal?

Various answers have been given to this question.¹

The opinion first entertained and that which is generally still current among common people, was that the continental forests were limited by fires. The Indians started fires and these fires were slowly, at the advent of the white man, consuming the woods, had stripped large areas in the Mississippi valley and unchecked would eventually have reached the Atlantic coast. No one who has been an eye-witness of the conflagrations that once rolled in annual tides across Iowa or Illinois can doubt the force of the theory so long and so widely entertained. The difficulty lies in the fact that the forest stood the attack so well, in fact seemed largely unaffected, actually held its own in nearly every part of the fire-infested district. Then again, if the truth had been that the aborigines were destroying the woods at the time when the whites first became witnesses, proof of the fact should be found over the whole region in form of charred logs, stumps, etc., of which, needless to remark, there has been no trace whatever. The fire theory not wholly satisfactory, some students went to the other extreme and urged that the distribution of the woods was due to causes efficient in times remotely past, so that fires or present conditions had nothing at all to do with the matter; the solution of the problem must be sought in some earlier geologic age. Others again sought to solve the problem by *a priori* method. It was urged that trees exhaust the soil of one set of elements while grasses, herbaceous plants, demand something entirely different, so that either set of plants occupying for long ages a given region would exhaust its availability though leaving the ground serviceable for something else. Thus trees once occupied the whole Mississippi valley but had exhausted the ground of tree-material, so to speak, had worn out their welcome. The answer to this is that here in Iowa trees seem to grow everywhere if planted and cared for.

¹See *inter al.* Am. Journal of Science VI, 334; XXXVIII, 332 and 344; XXXIX, 317; XL, 23 and 293. Geol. Survey of Illinois I, 238 *et seq.*; Geology of Iowa, Hall, I. Part I, p. 23 *et seq.*; U. S. Geol. Survey, Eleventh Annual Report of the Director, p. 236 *et seq.*

Prof. Lesquereux carries the idea of suitability of soil a little farther. He traces all prairies to old time lakes; declares that prairie soil is "neither peat nor humus, but a soft, black mould, impregnated with a large proportion of ulmic acid, produced by the slow decomposition, mostly under water, of aquatic plants, and thus partaking as much of the nature of peat as of that of true humus." * * * "It is easy to understand," he says, "why trees cannot grow on such kind of ground. The germination of seeds needs free oxygen for its development, and the trees, especially in their youth, absorb, by their roots, a great amount of air, and demand a solid point of attachment to fix themselves, etc." That is, the reason why our prairies are treeless is that they are too wet, and they contain, in virtue of their origin, certain elements to trees inimical. Professor Whitney also finds explanation of our prairies in the nature of the soil, "as the prime cause of the absence of forests and the predominance of grasses over this widely extended region. And although chemical composition may not be without influence in bringing about this result, * * * yet we conceive that the extreme fineness of the particles of which the prairie soil is composed is probably the principal reason why it is better adapted to the growth of its peculiar vegetation than to the development of forests."

Whitney makes also another very suggestive statement, the importance of which he did not himself realize. He says: "Wherever there has been a variation from the usual conditions of soil on the prairie or in the river bottom there is a corresponding change in the character of the vegetation. Thus on the prairie we sometimes meet with ridges of coarse material, apparently *deposits of drift*, on which from some local cause there has never been an accumulation of fine sediment; in such localities we invariably find a growth of timber. This is the origin of the groves scattered over the prairies for whose isolated circumstances and peculiarities of growth, we are unable to account in any other way."

It is interesting to notice the emphasis which Whitney here places on the character of this soil. No doubt there is something about prairie soils which makes them different from all other soils with which we are acquainted, and no doubt difference in soils is responsible for the difference in the forms of vegetation which they carry, but while both these excellent students, Lesquereux and Whitney, came in their surmises

very near the truth each of them in his theory missed the mark. It remained for an almost lifelong resident of the prairie, a former active member of this academy, to study to better purpose, Iowa's forest distribution, when, as a vigorous geologist he made his now famous pilgrimage through our eastern counties. Mr. McGee was quick enough to notice that the soils of our prairie region are indeed peculiar, and of several sorts, and that the vegetation varies with the soil, but he went farther: he referred the whole problem back to conditions geological, to a situation resultant from the nature and manner of the latest geological deposit. The soils of Iowa are three, the drift of the prairie, the loess of the hills, the alluvium of the river flood-plains, and Mr. McGee's contribution to our problem lies in his emphasizing the fact first noticed by Whitney, that the forests and groves of Iowa, except where alluvial, are everywhere coterminous with the distribution of the loess. Since Mr. McGee has called attention to the fact, of course, everybody sees it. The merest tyro in such studies has but to drive across some eastern county of our state to see how very striking the relation is. Every hill is clay-capped, and every clay-capped ridge is covered with woods. Sometimes the clay is replaced by sand, but the woods cover the sand, as Whitney says, just the same.

There is one other fact, however, to which attention has not yet been called, which has a distinct bearing upon our problem and that is the fact that subsequent to the occupancy of the state by civilization the forest began slowly to enlarge. Many localities might be cited in proof of this statement. I have in mind one field of thirty acres in 1844 cultivated as a cornfield, now used year after year as a grove for Fourth of July celebrations. Then again, as Whitney remarked, trees grow on all the alluvial soils of Iowa, so that outside the fact of soil-difference, there must be still a factor operating to make the difference in soil efficient. That factor in my opinion is that already mentioned as of universal popular appreciation, namely, *fire*. Fires have prevailed on the continent not only for generations as man reckons the years, but for forest-generations for hundreds and hundreds of years. In the presence of fires forests endure only as they have some special defense. This may be found in one or both of two conditions; in a limited amount of surface-moisture or in lack of combustible material on the surface of the ground. The alluvium offers both conditions; the

loess the latter. That is, to be more explicit, the loess with its sand and clay is a soil for cereals so poor as to raise but a small crop of grass, hence to furnish for sweeping fire a small amount of fuel, hence giving rise to less destructive fires, in which young trees were not universally destroyed. The drift on the other hand produces enormous wealth of grass, burning in conflagration which no seedling trees can endure; hence on the drift there are no trees. The presence of trees on rocky soils is to be explained in the same way. River bottoms furnish a special case. Here in the first case the current formed soil is in the nature of a sand bar, made of the coarser elements met with by the eroding flood. On sand bars cottonwoods and willows start, but not grass. The soil after a little becomes richer it is true, by subsiding slime, but by this time the locality is become moister than all the surrounding region; in summer, being lower, receiving heavier dews; in winter catching and longer retaining a larger proportion of snow, all tending as check to sweeping fires.

In conclusion, we are therefore prepared to say that all the students of our problems have been right, though each presented but a partial truth. Those who affirmed the agency of fire were right, but they failed to notice the fire's selective operation or to explain it. Those who attributed forest distribution to differences in soil were also right, but they failed to show or see how or why such difference availed. Those who looked back to a former geologic age were also right, but such failed entirely to show what the influence was which geologic structure has upon the problem.

To sum up: (1) The immediate agent in the limitation and distribution of Iowa forests was fire. (2) The sweep of fire was determined by a modicum of moisture and by the presence of *fuel upon the ground*. (3) The drift being especially adapted to gramineous vegetation, furnished fuel in such amount as to prevent the development of tree-seedlings, while the loess, using the term in a broad sense, less suited to gramineous species, furnished less fuel, hence gave to tree seedlings on loess regions opportunity to rise. (4) Special localities, as swamps, alluvial flood-plains, etc., present special cases and require special explanations.

As a corollary we may remark: (1) That the drift-plains of the state offer greatest promise to the farmer who seeks the cereals as his principal product. The wooded regions should

be left to woods as to their appropriate crop. The loess clay will never enable its cultivator to compete with his more fortunate fellow-citizen who farms the drift, and the sooner the people of Iowa find it out the better. (2) It is likely that orchards and vineyards will thrive better on the loess than on the drift, as trees generally may be supposed to have been subject to similar discipline in all time and in all parts of the world.

THE NOMENCLATURE QUESTION AMONG THE SLIME-MOULDS.

BY T. H. MACBRIDE.

That a man's difficulties are often of his own creating is a fact patent in science as in other fields. The imperfections of our methods form ever increasing nets of complexity about the feet of our progress. No one feels this more keenly than the naturalist, especially he who would attempt to give more exact account of some limited group or series of animals or plants. No matter how carefully he may arrange his materials, no matter how industriously he may have worked out the various problems of structure and morphology, there comes at last to plague him, to hinder him, to mar his purpose and waste his time, the question of nomenclature; his specimens must be named. This ceremony, the christening, which ought to have been the simplest matter in the world, has really become, if not the most difficult, at least the most annoying and thankless portion of his task. Preposterous also as it may seem, it is precisely the oldest and most universally recognized of the forms with which he deals that are apt to give the most trouble. There has arisen a class of critics among us who have devoted their energies to the unsettling of scientific nomenclature in every department of research, with the result that, rightly or wrongly, every systematic work in the world needs revision if not re-writing, and every herbarium in the world needs a new set of labels. Now, this might all not be so bad if such a revolution were final. If the wheel were only weighted on one side, so that once it came to rest we could feel

that there it would stay, we might put up with temporary confusion in view of the peace that should certainly follow. But the revisers are by no means agreed among themselves. We are watching a wheel which is weighted, not on one side only, but on two or three different sides, and we not only have no idea which side will eventually determine equilibrium, but we are certain that any repose we may secure is liable to be instantly and forever jeopardized by the first crank who chooses to give our wheel again a whirl. Meanwhile revision and re-naming go merrily on. Rules have been adopted by bodies more or less representative, first on one side of the Atlantic then on the other, but neither do these rules agree one with another. The zoologists have their set of rules to which some are obedient, others not. The botanists have their set of rules which have gotten so far as to be liable to be submitted to a world's botanical congress, did such ever convene. Meantime, while nothing is settled, at least by anything like universal consensus of opinion, there are men who devote their energies, not to the pursuit of science, but of priority; who are forever claiming to find in the work of some obscure naturalist of a preceding century for common objects names different from those in universal use, and all the world must perforce stop in its real pursuit of knowledge to see what must be done with these disturbers of the peace, until we are in danger of presenting to our successors, if they heed us at all, the spectacle of a generation of so-called scientific men giving more heed to names than to things.

Now all this is trite enough. Moreover the question of nomenclature is a real one, a very real one, as it has to do with an instrument of research, and it is one of those questions that never can be settled until settled right.

It is not in the hope of being able to contribute far towards such settlement that the present paper is submitted, but rather to point out some of the difficulties to be encountered by one who attempts to deal with nomenclature, even in a group of organisms confessedly small.

As is well known the Myomycetes are a group of saprophytes, for a long time classed with the fungi and especially with the *Gastromycetes*, puff-balls, stink-horns and the like, and only recently, i. e., within twenty or thirty years, thoroughly studied and understood. Although not understood, not primarily properly referred at all, mycologists were continually

collecting them, in a fashion describing them, naming and occasionally figuring them. In 1873-75 Rostafinski, under direction of De Bary, undertook the first systematic presentation of the group as a whole, properly separating the slime moulds from the fungi, basing subsequent classification upon characters unused before, characters chiefly microscopic, and for the first time in the case of the great majority of the forms studied, offered specific descriptions sufficiently exact, and presented intelligible figures. I have said that Rostafinski based his specific descriptions upon characters revealed by a microscope: not only so but it must be considered that his work was effected by the aid of a *good* microscope, one which enabled him to go into details of spore measurement, spore sculpture and so on, to an extent to his predecessors undreamed, to most of them indeed impossible. In the preparation of his classic, he had access to all the literature of his subject and generally employs for genera and species names already in use. Furthermore he gives for all such species a synonymy which must strike every student as liberal in the extreme. For instance, in the case of *Fuligo varians* Sommf., the synonyms quoted number 42. But when it comes to selecting the particular name which he has adopted, Rostafinski was often somewhat arbitrary. Not only does he discard often the specific name which by his list of synonyms has conceded priority, much less does he follow the rule which adopts "the name given first with the genus in which the species now stands," but he seemed often to discard any and all names, and to name his species without regard to any rule, but purely in accord with his own taste or preference.

For twenty years Rostafinski's work has been unassailed, partly because of its inherent excellence and the great name of his master De Bary, which seemed to stand as a guarantee behind it, and partly no doubt because of the unintelligible Polish dialect in which the book was given to the world. The Germans let the thing alone as *opus perfectum*, the English botanists were content with Cooke's paraphrase and there the matter stood. Masee, in his Monograph of 1892, followed almost implicitly the Rostafinskian nomenclature, and even quoted his synonyms *intoto*. Meantime some continental writers, as Rannkier in Denmark, were becoming reckless, and Mr. Lister the latest English monographer, was preparing to overturn the whole Rostafinskian list. This author is not only extremely radical in his omission and consolidation of pre-

viously recognized species but adopts as his guide in nomenclature the rule "laid down by A. L. Condolle in 1868, * * * that the first authentic specific name published under the genus in which the species now stands shall take precedence of all others;" a rule which seems to me as unfair in its proposals as absurd in the results to which it leads. Under the operation of this rule Rostafinski's synonyms is made to overturn his own nomenclature, and this in a multitude of instances.

Now, I have no disposition to defend Rostafinski. As before said, his nomenclature, whatever apology we may offer, admits in many cases of small defense; but in fact Rostafinski needs no defender. If any man chooses some other prior name for a species listed by the illustrious Pole, upon him devolves the burden of proof; he must show that the form described by Rostafinski is that referred to by the earlier author. No one who has studied these forms and has attempted their specific identification, even with the most carefully drawn descriptions before him, but will appreciate the futility of an effort to apply the old and brief descriptions. Even so-called authentic specimens are hard to authenticate. Slime-moulds are perishable things and labels are liable to become mixed, even in the best herbaria as we all know. To aver of a species described by Rostafinski that it is the same as that sketched in a line or two by Persoon or Link, is an undertaking too bold for me. Even where the species described is figured, the figure is often perfectly valueless for complete assurance. Take Schrader for instance, whose copper plates of a hundred years ago are among the best pre-Rostafinskian illustrations in the group we study, and even these are disappointing in the extreme. The figure of *Dictydium umbilicatum* S. is portrayed in life-like fashion but is unluckily an only species. The species of *Cribraria* to which Schrader gave name, are some of them fairly shown but not in the details by which the species may be everywhere distinguished. *C. macrocarpa* the artist missed entirely and fell instead into a bit of arabesque which has nowhere the slightest counterpart in nature. Schrader's descriptions are very much better than those of most writers of his day, and yet they fail to distinguish as we now discriminate since Rostafinski taught us how. The fact is that when Rostafinski gives credit to his predecessors it is for the most part purely a work of courtesy and grace. There is nothing in the work itself to command such consideration. The man who in his search for

priority ascends beyond Rostafinski, does it therefore at the risk of endless confusion and uncertainty in the great majority of cases. Some years ago the botanists present at the session of the A. A. A. S., concluded that in describing Phenogams one should not transcend a particular edition of Linnæus; a better rule is that which ascends to the earliest accurate description; no farther. Accordingly for the great majority of slime-mould species I should draw the line at Rostafinski's work, 1875.

The exceptions are the few which the rule of accurate description would carry behind the Polish publication, where Rostafinski discarded a name simply because for some reason or other Rostafinski did not like it. As an illustration, take the little, not uncommon, species called by Rostafinski—

Cornuvia circumscissa (Wallr.) R.

The synonyms, as quoted by Rostafinski, are:

Lignidium quercinum Fr. 1825.

Trichia circumscissa Wallroth. 1833.

Arcyria glomerata Fr. 1849.

Ophiotheca chrysosperma Currey. 1854.

Trichia curreyi Cronan. 1867.

The only names accompanied by their authors by descriptions at all definitive are the last two. The genus *Lignidium*, as defined by Link, certainly referred to forms belonging to the *Physareæ*, if to *Myomycetes* at all, so that that generic name cannot stand, nor can Fries have had our species in mind, since his description refers, probably, to some *Physarum*. *Trichia circumscissa* Wallr. undoubtedly comes nearer to it, but our species is not circumscissile, so that it is doubtful whether Wallroth, even, had in view the same species. Currey, who comes next on the list, by judicious description and carefully drawn figures, having, as we think properly, separated from the *Trichias* the genus *Ophiotheca*, ignored all preceding specific names, supposing any to have been up to this time affixed, and called the species we have before us *O. chrysosperma*. Rostafinski now recognizes Currey's work, but rejects his generic name on the grounds of inapplicability in primary significance to all the species included. He therefore coins a new generic name—*i. e.* *Cornuvia*—and goes back to Wallroth for specific name, a thing that Currey should have done had Wallroth's description been of sufficient exactness to make sure to Currey's mind, as it seems it did to Rostafinski's, that Wallroth was actually describing the same specific form. The criticism of Rostafinski will,

therefore, in this instance, change the commonly received name. Instead of *Cornuvia circumscissa* (Wallr.) R., we shall say *Ophiotheca chrysosperma* Currey, unless we can show that Wallroth actually described the same thing, when, of course, we should write *Ophiotheca circumscissa* (Wallr.), followed by the name of the author who first established the combination, in this case, Massee.

NOTES ON THE FLORA OF WESTERN IOWA.

BY L. H. PAMMEL.

The flora of the loess in western Iowa is unique, in many respects. While it may be said that many parts of the state have a typical prairie flora, certain species being common from Texas to British America, east to Wisconsin, Illinois and Indiana, only occasionally do we find plants of the great plains in our own state. Western species are somewhat unequally distributed in our state; they occupy a larger area in northwestern Iowa than in southern and western. In northern Iowa a few prominent types appear, as in Emmet county. Of these I may mention *Bouteloua oligostachya*, *Agropyrum caninum*, *A. caesium*, *Grindelia squarrosa*, *Helianthus Maximiliani*. The latter is not, however, a typical western plant, though introduced in central Iowa. It crosses our western border on the loess and extends south to Texas.

The loess of western Iowa is peculiar so far as the flora is concerned, nothing like it in Iowa. A number of American writers have written upon the peculiarities of its plant life. B. F. Bush¹ has given us a complete catalogue of the flora of northwestern Missouri.

A. S. Hitchcock² has reported a few of the plants occurring near Sioux City, and in general touches on the flora of western Iowa.

J. W. McGee considers the loess flora of northeastern Iowa. The two regions are however not similar from a botanical standpoint. It may be well to speak of the formation in this

¹Notes on the mound flora of Atchison county, Missouri. Reprint, Sixth Ann. Rep. Missouri Botanical Garden, 1895, pp. 121-134.

²Notes on the flora of Iowa, Bot. Gazette, Vol. XIV, p. 127

connection. McGee³ says: "The macroscopic characters of the deposit are moderately constant:

"(1) It is commonly fine, homogeneous, free from pebbles or other adventitious matter, and either massive or so obscurely stratified that the bedding plains are inconspicuous; (2) it commonly contains unoxidized carbonate of lime in such quantity as to effervesce freely under acids; (3) it frequently contains nodules and minute ramifying tubules of carbonate of lime; (4) in many regions it contains abundant shells of land and fresh water mollusca; (5) is commonly so friable that it may be removed with a spade or impressed with the fingers, yet it resists weathering and erosion in a remarkable manner, standing for years in vertical faces and developing steeper erosion slopes than any other formation except the more obdurate clastic or crystalline rocks." McGee also states that it is a fallacy to regard the loess as identical in composition or that it is identical in genesis or even in age. As to its origin, Chamberlin and Salisbury find that in western Wisconsin and contiguous parts of Illinois and Iowa its composition varies in different localities with that of the associated drift and that both composition and distribution point to glacial silt as the parent formation of the loess in the upper Mississippi valley. Prof. McGee in speaking of the plants of the loess in northeastern Iowa lays stress on the prevalence of hard wood forests in the area. That the timber belt is confined to this area. The chief trees of this region from my observations are, oaks a half dozen species (*Quercus macrocarpa*, *Q. coccinea*, *Q. tinctoria*, *Q. rubra*, *Q. alba*, *Q. Muhlenbergii*, *Q. bicolor*). The *Q. bicolor* is however, a swamp species. The latter and *Q. Muhlenbergii* are southern species that have extended northward along the Mississippi. The butternut (*Juglans cinerea*) of the uplands and walnut (*Juglans nigra*) of the bottoms, the former is northern and the latter southern. The genus *Prunus* is represented by three species (*Prunus Americana*, *P. serotina*, and *P. Virginiana*). The crab-apple (*Pyrus coronaria*) is found everywhere in thickets. The white birch (*Betula papyracea*) is a rare tree, the river birch (*Betula nigra*) is abundant along the streams; other trees along streams are honey locust (*Gleditschia triacanthos*); sycamore (*Platanus occidentalis*) Kentucky coffee tree (*Gymnocladus Canadensis*), all southern representatives. The elms are represented

³The Pleistocene history of northeastern Iowa, Eleventh Ann. Rep. U. S. Geological Survey, p. 291.

by three species (*Ulmus Americana*, *U. racemosa* and *U. fulva*). Only one, the slippery elm, is abundant on the loess formation, though *Ulmus Americana* is less restricted to low bottoms than *U. racemosa*. Of the maples the sugar maple (*Acer saccharinum*) is common on the loess, while the soft maple (*Acer dasycarpum*) is exclusively a lowland species, so is box elder (*Negundo-aceroides*). The mountain maple (*Acer spicatum*) occurs on the loess. *Tilia Americana* is common on the loess formation. Three cone bearing trees occur in northeastern Iowa (*Abies balsamea*, *Pinus Strobus* and *Juniperus Virginiana*), but they occur on other than loess soil. Of the ashes there are several species the *Fraxinus viridis* delights in low bottoms. The *F. Americana* occurs on higher soil.

I cannot, in this connection, enumerate the shrubs that occur, but they are numerous and may occur in thickets in both loess and bottoms. Comparing the plants found in northeastern Iowa with those about La Crosse, Wis., where my early botanical work was done, I may say that most of the species occur and that the woody plants are more numerous. Some of the southern species, however, fail to appear, but in places northern forms occur. The density of the timber increases from the Mississippi east. In the drainage basin of the Kickapoo Valley the finest timber in western Wisconsin occurs. Nowhere have I seen such beautiful specimens of *Acer saccharinum*, *Tilia Americana* and *Quercus macrocarpa*. This, too, is outside of the loess region. In southwestern Minnesota, the statement of McGee that there is a significant relation between the loess sheeting and forest covering is very apparent.

The most significant fact appearing to one who has made a study of the loess flora of western Iowa is the absence of trees, except an occasional cottonwood, on the peculiar mounds that occur in parallel ridges along the Missouri river. These peculiar hills rise abruptly from the rich, fertile Missouri bottom and somewhat resemble the low foot hills of the Rocky mountains. They are from 100 to 200 feet high. From a distance they look bare, but a day spent in this region will show that the hills are full of botanical interest. I have made four botanical trips at different times along the Missouri. On the whole there is very little variation in the flora of Iowa. If we leave out of consideration a number of most interesting plants found in Winneshiek county by Mr. Holway and a few peculiar southern plants found by Mr. Ferd Reppert, near the city of

Muscatine, the only radical difference shown in our flora is that occurring along the Missouri. About twenty-five western and northwestern species occur and, according to the list of Mr. Bush, nearly the same species occur from Sioux City, Iowa, to St. Joseph, Mo. The region is not entirely devoid of trees, in its northern portion, between the steep mounds a variety of bur oak (*Quercus macrocarpa* var. *olivaeformis*), Slippery elm (*Ulmus fulva*), Cottonwood (*Populus monilifera*), Plum (*Prunus Americana*), Basswood (*Tilia Americana*), box elder (*Negundo aceroides*), occur. Several shrubs also occur; Grape (*Vitis riparia*), climbing bittersweet (*Celastrus scandens*), wahoo (*Euonymus atropurpureus*). South, the timber area is more extensive, as at Council Bluffs and Missouri Valley. At Glenwood and Logan there are fine specimens of *Quercus rubra*, *Tilia Americana* and *Ulmus fulva*. They are abundant from one-half to two miles from the hills. The trees on the loess about Turin and Sioux City are broad and spreading.

Of the peculiar herbaceous plants, I shall content myself by giving a list. The beautiful Spanish bayonet (*Yucca angustifolia*) so abundant everywhere in the west. The *Aplopappus spinulosus* forms dense mats on the tops of the mounds. *Grindelia squarrosa*, now naturalized in other parts of Iowa. *Liatris punctata*, *Euphorbia marginata*, *E. heterophylla*, a beautiful blue-flowered lettuce (*Lactuca pulchella*), *Gaura coccinea*, so abundant everywhere in Nebraska and in the Rocky mountain region. *Oxybaphus angustifolia*, *Helianthus Maximiliani*, *Lygodesmia juncea*, an abundant plant of the plains now exerting itself with great force in the cornfields of northwestern Iowa. The beautiful *Mentzelia ornata* is confined to Cedar Bluffs along the Big Sioux a few miles north of Sioux City. *Cleome integrifolia*, the celebrated Rocky Mountain bee plant. Two species of *Dalea* (*D. alopecuroides* and *D. laxiflora*) the Loco weed (*Oxytropis Lamberti*) and *Astragalus lotiflorus*, var. *brachypus*. Professor Hitchcock records *Stipa comata*, which belongs chiefly to the Rocky Mountain region and rarely found in eastern Nebraska. *Shepherdia argentea* occurs along the Missouri near Sioux City undoubtedly a waif from the northwest.

I may also add a gamma grass peculiar to the west, most common species of Nebraska (*Bouteloua oligostachya*) Buffalo grass (*Buchloe dactyloides*) from Lyon county. The most abundant grasses on the hills are *Andropogon scoparius*, *Bouteloua racemosa*, quite common in many parts of Iowa. *Muhlenbergia*

soboliferia, *Ammophila longifolia* and *Sporobolus Hookeri*, *S. brevifolius* and an unnamed western species which has heretofore been referred to *S. cuspidatus*. I may also remark that a peculiar thistle occurs, the *Onicus altissimus*, var. *fililpendulus*.

Why is it that these peculiar hills, not more than a few hundred feet wide, should have such a local western flora? The soil is retentive of moisture, it dries out quickly and the roots easily penetrate the soil to draw on the contained moisture below. This certainly cannot be the reason, since the loess extends along the river courses in the interior. Some of these plants, since the cultivation of the soil, have shown some tendency to spread, as in *Euphorbia marginata*, *Lygodesmia juncea*, *Grindelia squarrosa*, which are tramping eastward to menace the farmer.

Were the seeds of some of these plants brought to Iowa with the buffalo, as has been suggested for buffalo grass? Some of the plants are disseminated by the wind, and in others the water can by a purely mechanical means bring them to the base of the mound. With the more woody country of southeastern Iowa there seems to have been but little chance for these plants to spread beyond the bluffs. In northwestern Iowa some of these plants, like *Helianthus Maximiliani*, are not uncommon, which shows that the woody area of southwestern Iowa is in part a barrier against a further eastern extension. But why did the plants not extend beyond the very narrow limits, as the forest area does not encroach directly on the loess mounds? I am at a loss to explain this most peculiar distribution.

In the list appended I enumerate the most striking plants. The writer is under obligations to Mrs. Rose Schuster Taylor and Miss Bandusia Wakefield, of Sioux City, for favors rendered; also Mr. E. D. Ball, of Little Rock; Mr. W. Newell and J. Jensen, of Hull, and E. G. Preston, of Battle Creek, for specimens, to Dr. Millspaugh for naming the Euphorbias.

My own collections were made at various times near Sioux City, Hawarden, Onawa, Turin, Missouri Valley, Council Bluffs and Logan. The list could have been extended and localities added, but college material is not readily accessible at this time of the year. Miss Wakefield's list is based on colored sketches in her possession. I have abbreviated all specimens credited to her as (B. W.), and those collected by myself as (L. H. P.). I have followed Gray's Manual in arrangement of

orders, genera and species. It will not be necessary to comment on the value of this, since it is the standard work in the schools and colleges of Iowa.

RANUNCULACEÆ.

Clematis Virginiana L.

Sioux City, in woody ravines (B. W.).

Anemone patens L. var. *Nuttalliana* Gray.

Sioux City, prairies, abundant (B. W.).

Anemone cylindrica A. Gray.

Hull (W. Newell); Little Rock, dry grounds (Herb. C. R. Ball).

A. Virginiana L.

Sioux City (B. W.).

A. Canadensis L.

Sioux City, low grounds, bottoms (B. W.); Little Rock (Herb. C. R. Ball).

Thalictrum purpurascens L.

Sioux City, low grounds and prairies (B. W.); Hull (W. Newell); Little Rock (C. R. Ball).

Ranunculus Cymbalaria Pursh.

Hull (W. Newell); Little Rock (Herb. C. R. Ball).

R. multifidus Pursh.

Little Rock, in water (Herb. C. R. Ball).

R. abortivus L.

Sioux City (B. W.).

R. septentrionalis Poir.

Cherokee (B. W.).

Caltha palustris L.

Sioux City, not common, low marshes (B. W.).

Aquilegia Canadensis L.

Sioux City, abundant in wooded ravines (B. W.).

Delphinium azureum Michx.

Sioux City prairies (B. W.); Little Rock (C. R. Ball); flowers of Iowa specimens are greenish white.

Actaea spicata L. var. *rubra*, Ait.

Sioux City woods, frequent (B. W.).

MENISPERMACEÆ.

Menispermum Canadense L.

Sioux City, common, in wooded ravines (B. W. L. H. P.).

BERBERIDACEÆ.

Caulophyllum thalictroides, Michx.

Sioux City woods, frequent (B. W.).

NYMPHAEACEÆ.

Nelumbo lutea Pers.

Onawa (B. W.).

Nymphaea reniformis D. C.

Lyon Co. (B. W.).

Nuphar advena Ait.

Sioux township Lyon Co , northwest corner of state (B. W.).

PAPAVERACEÆ.

Sanguinaria Canadensis L.

Sioux City. Wooded ravines (B. W.).

FUMARIACEÆ.

Dicentra cucullaria D. C.

Sioux City, abundant in wooded ravines in vegetable mould.

Corydalis aurea Willd.

Sioux City, borders of woods, common (B. W.).

CRUCIFERÆ

Lepidium Virginicum L.

Sioux City, waste places abundant (B. W.)

L. apetalum Willd.

Not represented by specimens though abundant on mounds, fields and pastures in western Iowa (L. H. P.).

Capsella Bursa-pastoris Medic.

Sioux City (B. W.).

Brassica nigra Koch.

Sioux City (B. W.).

B. Sinapistrum Boiss.

Sioux City (B. W.).

Sisymbrium officinale Scop.

Sioux City (B. W.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); roadside weed.

S. canescens, Nutt.

Sioux City (B. W.).

Erysimum cheiranthoides L.

Sioux City, rich soil, river bottoms (B. W.).

Nasturtium terrestre R. Br.

Sioux City (B. W.) low grounds; borders of ponds and streams.

Cardamine hirsuta L.

Little Rock (C. R. Ball).

Arabis, hirsuta Scop.

Sioux City (B. W.).

CAPPARIDACEÆ.

Polanisia graveolens, Raf.

Sioux City (B. W.).

Cleome integrifolia Torr. & Gray.

Onawa, Missouri Valley streets and loess mounds (L. H. P.) common (B. W.); common in the city (L. H. Pammel); from observation.

VIOLACEÆ.

Viola pedatifida Don.

Sioux City, prairies frequent (B. W.).

A. palmata L. var. *cucullata* Gray.

Sioux City, common in woods (B. W.).

Viola Canadensis L.

Sioux City, wooded ravines between loess mounds east of Sioux City (B. W.). Apparently out of its range.

CARYOPHYLLACEÆ.

Saponaria officinalis L.

Sioux City, escaped from cultivation (B. W.).

Silene stellata Ait.

Sioux City, woods common (B. W.); Hawarden, Council Bluffs, common borders of woods (L. H. P.).

Lychnis Githago Lam.

Sioux City, an introduced weed (B. W.); Rock Valley (Jensen & Newell); Little Rock (Herb. C. R. Ball).

Stellaria longifolia Muhl.

Sioux City (B. W.); Little Rock (C. R. Ball).

PORTULACACEÆ.

Portulaca oleracea L.

Sioux City (B. W.); an abundant weed everywhere in western Iowa.

Talinum teretifolium Pursh.

Sioux City (B. W.).

Claytonia Virginica L.

Smithland, in woods (B. W.).

MALVACEÆ.

Malva rotundifolia L.

Turin, Onawa, weed in streets and along roadsides (L. H. P.); Sioux City (B. W.); Little Rock (C. R. Ball).

Abutilon Avicennae Gaertn.

Onawa, streets and waste places, abundant (L. H. P.); Sioux City (B. W.).

TILIACEÆ.

Tilia Americana L.

Sioux City, Turin, Missouri Valley, Council Bluffs, ravines between loess mounds (L. H. P.); back of mounds an abundant tree.

LINACEÆ.

Linum sulcatum Riddell.

Sioux City, top and sides of loess mounds, prairies (L. H. P.), (B. W.); Little Rock (C. R. Ball).

L. rigidum Pursh.

Sioux City, loess mounds, capsules and old stems only found by myself (L. H. P.); Hamburg (Hitchcock, Bot. Gazette, XIV, 128).

GERANIACEÆ.

Oxalis violaceæ L.

Sioux City, in woods frequent (B. W.); Little Rock (Herb. C. R. Ball).

O. corniculata L. var. *stricta* Sav.

Turin, Onawa, in woods and fields abundant (L. H. P.); Sioux City (B. W.).

Impatiens pallida Nutt.

Sioux City, in woods along streams (B. W.).

I. Fulva Nutt.

Sioux City, in woods along streams (B. W.).

RUTACEÆ.

Xanthoxylum Americanum Nutt.

Sioux City, common in woods (B. W.); South Dakota, opposite Hawarden, in valleys between hills (L. H. P.).

CELASTRACEÆ.

Celastrus scandens L.

Sioux City, common in woods between loess mounds (B. W. and L. H. P.).

Euonymus atropurpureus Jacq.

Sioux City, in woods between loess mounds (B. W., L. H. P.); South Dakota, opposite Hawarden (L. H. P.).

RHAMNACEÆ.

Rhamnus lanceolata Pursh.

Logan, low hills in woods (L. H. P.), Sioux City, level woodland near the Big Sioux river (B. W.).

Ceanothus Americanus L.

Turin, Missouri Valley, loess hills in open, grassy places
(L. H. P.); Sioux City (B. W.).

C. ovatus Desf.

Council Bluffs, sides and tops of loess mounds (L. H. P.).

VITACEÆ.

Vitis riparia Michx.

Sioux City, valleys between loess mounds in woods (L. H. P.);

South Dakota, opposite Hawarden (L. H. P.).

Ampelopsis quinquefolia Michx.

Sioux City, in woods; common (B. W.).

SAPINDACEÆ.

Acer dasycarpum Ehrh.

Sioux City, Hawarden; abundant in alluvial bottoms, along
Big Sioux and Missouri rivers (L. H. P.).

Negundo aceroides Moench.

Sioux City, frequent along streams (B. W.).

Staphylea trifolia L.

Sioux City, in valleys between loess hills (B. W.).

ANACARDIACEÆ.

Rhus glabra L.

Sioux City, common border of loess mounds (B. W.) South
Dakota, opposite Hawarden (L. H. P.).

R. Toxicodendron L.

Sioux City, common in valleys between loess mounds
(B. W.).

POLYGALACEÆ.

Polygala verticillata L.

Sioux City, loess mounds (L. H. P. and B. W.).

LEGUMINOSÆ.

Baptisia leucantha Torr. and Gray.

Battle Creek, low places, prairie (E. G. Preston), Cherokee
(B. W.).

Crotalaria sagittalis L.

Sioux City, bank of Big Sioux river, Cedar Bluffs (B. W.).

Trifolium pratense L.

Sioux City (B. W.).

T. stoloniferum Muhl.

Sioux City (B. W.).

T. repens L.

Sioux City (B. W.).

Melilotus officinalis Willd.

Sioux City (B. W.), Council Bluffs (L. H. P.).

M. alba Lam.

Sioux City, along railroads, in streets, fields and roadsides, abundant (L. H. P. and B. W.), Onawa, Turin (L. H. P.).

Medicago sativa L.

Sioux City, in streets; not common, Council Bluffs (L. H. P.).

Hosackia Purshiana Benth.

Sioux City, loess mounds (B. W.).

Psoralea argophylla Pursh.

Sioux City, abundant on loess mounds (B. W.), high prairies and low, rich soil; Little Rock (Herb. C. R. Ball), Hull (W. Newell). A typical prairie plant, common throughout Iowa on dry hills.

Amorpha canescens L.

Sioux City, bottoms (B. W.), Missouri Valley (L. H. P.).

Dalea alopecuroides Nutt.

Near Lake Okoboji (B. W.), Missouri Valley, Sioux City, loess mounds; abundant; Hawarden, in open grounds (L. H. P.), Hamburg (Hitchcock Bot. Gazette, XIV, 128).

D. laxiflora Pursh.

Sioux City (B. W.). The species is abundant on the loess mounds about Sioux City, Missouri Valley and Turin, producing a long and thick root. Hamburg (Hitchcock, Bot. Gazette, XIV, 128).

Petalostemon violaceus Michx.

Sioux City abundant on loess hills (B. W., L. H. P.); Hull (W. Newell); South Dakota opposite Hawarden dry hills (L. H. P.); Logan (L. H. P.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Council Bluffs dry hills (L. H. P.); Missouri Valley, Turin, loess hills (L. H. P.). On loess mounds, usually with shorter heads than commonly found on prairies.

P. candidus Michx.

Sioux City, hills loess abundant; L. H. P. South Dakota opposite Hawarden (L. H. P.); Hull (W. Newell); Battle Creek (E. G. Preston); Little Rock (Herb. C. R. Ball); Council Bluffs, Turin, Missouri Valley, on loess mounds, shorter heads and smaller plants than commonly found on prairies.

Robinia Pseudacacia L.

Sioux City, an escape from cultivation (B. W.).

Astragalus caryocarpus Ker.

Sioux City (B. W.).

A. Canadensis L.

Sioux City (B. W.).

A. lotifloris Hook var. *brachypus* Gray.

Hamburg, Hitchcock, Bot. Gazette XIV, 128.

Oxytropis Lamberti Pursh.

Sioux City (B. W.). Specimens in fruit were found near Turin and Missouri Valley on loess mounds (L. H. P.). Produces a perennial root several feet in length, frequently exposed where soil has washed away. Miss Wakefield finds the form with violet colored flowers more common than the white. Hamburg (Hitchcock, Bot. Gazette, XIV, 128).

Glycyrrhiza lepidota Nutt.

Sioux City (B. W.); Turin, Missouri Valley, along railroads, and border of hills common, Logan, Council Bluffs (L. H. P.). Hull (W. Newell); Little Rock (C. R. Ball).

Desmodium Canadense D. C.

Hull (W. Newell).

D. canescens D. C.

Sioux City, bottom (L. H. P.).

Apios tuberosa Moench.

Smithland, low grounds (B. W.).

Strophostyles angulosa Ell.

South Dakota, opposite Hawarden, flood plain of Big Sioux river (L. H. P.); Sioux City (B. W.).

Amphicarpaea monoica Nutt.

Sioux City (B. W.).

Cassia Chamæcrista L.

Missouri Valley, loess hills abundant (L. H. P.); Sioux City (B. W. and L. H. P.); South Dakota, opposite Hawarden (L. H. P.); Battle Creek (E. G. Preston).

Gymnocladus Canadensis Lam.

Sioux City (B. W.), abundant at the mouth of the Big Sioux river, in alluvial soil, base of hills (L. H. P.).

Gleditschia triacanthos L.

Sioux City, abundant along the river (B. W.).

Desmanthus brachylobus Benth.

Spirit Lake (B. W.).

ROSACEÆ.

Prunus Americana Marshall.

Council Bluffs, loess in valleys between mounds. South Dakota, opposite Hawarden forming thickets at the base of hills (L. H. P.), Sioux City (B. W.) the species forms dense thickets in western Iowa, fruit small.

P. Virginiana L.

Logan, in valleys between hills. Sioux City (B. W.); the species occurs in thickets mostly small shrubs.

Rubus strigosus Michx.

Sioux City, rare (B. W.).

R. occidentalis L.

Sioux City, not common (B. W.).

Geum album Gmelin.

Logan, in woods (L. H. P.); Sioux City (B. W.).

Fragaria Virginiana Mill. var. *Illinoensis* Gray.

Sioux City (B. W.).

Potentilla arguta Pursh.

Hull (W. Newell); Battle Creek, (E. G. Preston); Little Rock, (Herb. C. R. Ball); Sioux City (B. W.). The species is frequent in dry places in western Iowa, loess mounds.

P. Norvegica L.

Hull (W. Newell); Little Rock (C. R. Ball); Rock Valley, (J. F. Jensen and W. Newell); Sioux City (B. W.).

Var. *millegrana* Watson.

Sioux City (B. W.).

Rosa Arkansana Porter.

Hull (M. Newell).

SAXIFRAGACEÆ.

Heuchera hispida Pursh.

Sioux City (B. W.).

Ribes gracile Michx.

Sioux City, in woods (B. W.) Council Bluffs, loess in woods (L. H. P.).

R. floridum L'Her.

Sioux City, in woods (L. H. P.); South Dakota, opposite Hawarden in woods, valleys and between hills.

CRASSULACEÆ.

Penthorum sedoides L.

Hull (W. Newell); Sioux City (B. W.).

ONAGRACEÆ.

Oenothera biennis L.

Hull (W. Newell); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Council Bluffs (L. H. P.). A weed in streets and waste places, and fields abundant throughout western Iowa.

O. serrulata Nutt.

Sioux City (B. W.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Hull (W. Newell). Praries and loess mounds abundant.

Gaura parviflora Dougl.

Sioux City, base of mounds (B. W.); Missouri Valley (L. H. P.). It is spreading eastward, occurring in meadows and fields.

G. coccinea Nutt.

Sioux City (B. W.) Missouri Valley, Turin top of loess mounds, common (L. H. P.); Hamburg (Hitchcock, Bot. Gazette XIV, 128).

LOASACEÆ.

Mentzelia ornata Torr. & Gray.

Sioux City on sandy and rocky bluffs along the Big Sioux river, Cedar Bluffs, abundant in that locality (B. W.).

CUCURBITACEÆ.

Echinocystis lobata Torr & Gray.

Turin, low ground along streams (L. H. P.).

CATACEÆ.

Opuntia Rafinesquii Englem.

Lyon county (B. W.).

UMBELLIFERÆ.

Heracleum lanatum Michx.

Sioux City (B. W.).

Pastinaca sativa L.

A roadside weed. Council Bluffs, Sioux City (L. H. P.).

Cryptotenion Canadensis D. C.

Sioux City (B. W.).

Zizia aurea Koch.

Sioux City (B. W.).

Cicuta maculata L.

South Dakota opposite Hawarden (L. H. P.); Sioux City (B. W.)

Osmorrhiza brevistylis D. C.

Sioux City (B. W.).

Eryngium yuccaefolium Michx.

Cherokee (B. W.).

CAPRIFOLIACEÆ.

Triosteum perfoliatum L.

Cherokee Co., Sioux City (B. W.)

Sambucus Canadensis L.

Sioux City (B. W.).

Symphoricarpos occidentalis Hook.

Sioux City, base of mounds; abundant (L. H. P. and B. W.); South Dakota, opposite Hawarden (L. H. P.); Battle Creek (E. G. Preston); Rock Valley (W. Newell and J. F. Jensen); Little Rock (C. R. Ball); Council Bluffs, Missouri Valley, Turin, base of loess mounds; abundant (L. H. P.).

RUBIACEÆ.

Houstonia angustifolia Michx.

Logan, hills; Council Bluffs, Missouri Valley, loess mounds (L. H. P.); Smithland (B. W.), common everywhere on the hills.

Galium Aparine L.

Sioux City (B. W.).

COMPOSITÆ.

Vernonia fasciculata Michx.

Hawarden, Missouri Valley, Turin, low grounds (L. H. P.); Sioux City (B. W.).

V. noveboracensis Willd.

Missouri Valley, Council Bluffs, loess mounds near base (L. H. P.).

Eupatorium purpureum L.

Sioux City (B. W.).

E. serotinum Michx.

Sioux City, Big Sioux bottom; not common (L. H. P.).

E. perfoliatum L.

Missouri Valley, low grounds (L. H. P.), Sioux City (B. W.).

E. ageratoides L.

Sioux City (B. W.); Onawa, in woods and low grounds (L. H. P.).

Kuhnia eupatorioides L.

Missouri Valley, Turin, loess mounds; Sioux City, loess mounds (B. W. and L. H. P.); Alton, prairies; South Dakota, opposite Hawarden (L. H. P.).

Liatris punctata Hook.

Missouri Valley, loess mounds (L. H. P.); Sioux City (B. W., L. H. P.); Hitchcock, South Dakota, opposite Hawarden, hills (L. H. P.).

L. scariosa Willd.

Alton, prairies, South Dakota, opposite Hawarden (L. H. P.).

Grindelia squarrosa Dunal.

Smithland (J. M. Wrapp), Sioux City, Hawarden, alluvial plain, Big Sioux river, abundant (L. H. P.); Battle Creek (E. G. Preston); Little Rock (Herb. C. R. Ball). Sioux City (Hitchcock, Bot. Gazette, XIV, 128).

Aplopappus spinulosus D. C.

Missouri Valley, Turin, Sioux City, tops of loess mounds, found in dense patches (L. H. P., B. W., Hitchcock, Bot. Gazette, XIV, 128).

Solidago speciosa Nutt.

Turin low grounds, border of woods (L. H. P.); Sioux City, base of hills (B. W.).

S. Missouriensis Nutt.

Turin, Missouri Valley, loess mounds common (L. H. P.).

S. serotina Ait.

Sioux City (B. W.).

S. rupestris Raf.

Sioux City, loess mounds (L. H. P.).

S. Canadensis L.

Sioux City, border of woods, thickets, roadsides, fences, pastures, abundant (L. H. P. B. W.); Onawa, Turin (L. H. P.).

S. rigida L.

Turin, loess hills (L. H. P.); Sioux City (B. W.).

Boltonia asteroides L'Her.

Missouri Valley, Turin, low bottoms, common (L. H. P.); Sioux City (B. W.).

Aster oblongifolius Nutt.

Turin, very abundant over loess mounds; South Dakota, opposite Hawarden, abundant all over low hills (L. H. P.); Sioux City, low mounds, common (B. W., L. H. P.).

A. Novae-Angliae L.

Turin, borders of woods, common; South Dakota, opposite Hawarden, few specimens near spring (L. H. P.); Sioux City (B. W.).

A. sericeus Vent.

Sioux Rapids, prairies, Turin, Missouri Valley, abundant over loess mounds (L. H. P.); Sioux City (B. W.).

A. sagittifolius Willd.

Turin, low grounds (L. H. P.).

A. ericoides L.

Turin, low grounds (L. H. P.).

A. multiflorus Ait.

Missouri Valley, open places, woods (L. H. P.); Sioux City (B. W.).

A. paniculatus Lam.

Sioux City, bottoms (L. H. P.); *A. ptarmicoides*, Torr. & Gray. Little Rock, prairies (Herb. C. R. Ball).

Erigeron Canadensis L.

Sioux City (B. W.); a weed in fields and pastures throughout western Iowa (L. H. P. observations).

E. strigosus Muhl.

Rock Valley (W. Newell, J. F. Jensen); Little Rock, prairies (Herb. C. R. Ball).

E. Philadelphicus L.

Hull (W. Newell); Sioux City (B. W.).

Antennaria plantaginifolia Hook.

Sioux City (B. W.).

Silphium laciniatum L.

Council Bluffs, common around loess mounds (L. H. P.); Sioux City (B. W.).

S. perfoliatum L.

Sioux City (B. W.).

Iva xanthiifolia Nutt.

Sioux City (B. W., L. H. P.); Onawa L. H. P.); Smithland (J. M. Wrapp). An extremely abundant weed everywhere in western Iowa, growing luxuriantly ten to twelve feet high in streets, vacant lots, dooryards, and around neglected buildings, etc.

Ambrosia trifida L.

Smithland (J. M. Wrapp); Sioux City (B. W.). A common weed along creeks and river courses in western Iowa (L. H. P.).

A. artemisiaefolia L.

Alton, Turin (L. H. P.); Sioux City (B. W.). A common weed in cultivated fields, pastures, meadows, along roadsides, vacant lots, and railroads.

A. psilostachya DC.

Council Bluffs, common weed along creeks and river courses in western Iowa (L. H. P.).

Xanthium Canadense Mill.

Sioux City, Turin (L. H. P.). In alluvial soil very abundant and weedy. South Dakota, opposite Hawarden, bottoms of Big Sioux river (L. H. P.).

Heliopsis scabra Dunal.

Sioux City (B. W.); Hull (W. Newell); Battle Creek, in woods (E. G. Preston); Little Rock (Herb. C. R. Ball).

Echinacea angustifolia DC.

Sioux City (B. W.); Hull (W. Newell); Battle Creek, abundant prairies (E. G. Preston); Council Bluffs, Logan (L. H. P.); Little Rock (Herb., C. R. Ball).

Rudbeckia laciniata L.

South Dakota, opposite Hawarden in woods abundant (L. H. P.); Sioux City (B. W.).

R. triloba L.

Onawa, low grounds, common (L. H. P.)

R. hirta L.

Sioux City (B. W.) Little Rock (Herb. C. R. Ball.).

Lepachys pinnata Torr. & Gray.

Sioux City (B. W.) Council Bluffs (L. H. P.).

Helianthus annuus L.

Sioux City (B. W.); Hawarden (L. H. P.); Onawa, Missouri Valley, (L. H. P.). A common weed everywhere in western Iowa, flood plains, Missouri and Big Sioux rivers, streets and dooryards. (L. H. P.).

H. rigidus Desf.

Hawarden (L. H. P.); Sioux City (B. W.).

H. grosse-serratus Martens.

Sioux City, abundant in alluvial bottoms of Missouri river, and along river courses, creeks (L. H. P., B. W.); Onawa, Turin. One of the most conspicuous plants in September.

H. Maximiliani Schrad.

Sioux City, Loess hills along the Missouri and Big Sioux rivers. Alton, Sioux Rapids, Hawarden, occasionally in alluvial bottoms at Whiting; also observed near Bradgate further east (L. H. P.).

H. tuberosus L.

Sioux City, between loess mounds, common, Hawarden,
Big Sioux bottom, common (L. H. P.).

Coreopsis palmata Nutt.

Sioux City (B. W.); Hull (W. Newell); Battle Creek (E. G.
Preston); Little Rock (Herb. C. R. Ball).

Bidens frondosa L.

Sioux City (B. W.).

B. chrysanthemoides Michx.

Sioux City (B. W.).

Helenium autumnale L.

Missouri Valley, low grounds, common (L. H. P.) Sioux
City (B. W.).

Dysodia chrysanthemoides Lag.

Sioux City, hills, waste places, streets, along roadsides
abundant (L. H. P., B. W.); Turin (L. H. P.).

Anthemis Cotula D. C.

Sioux City (B. W.); Little Rock (C. R. Ball).

Achillea millefolium L.

Sioux City (B. W.); Battle Creek, pastures (E. G. Preston);
Little Rock (C. R. Ball.).

Crysanthemum Leucanthemum L.

Sioux City; escaped from cultivation (B. W.).

Artemisia Canadensis Michx.

Sioux City (B. W., L. H. P.); South Dakota, opposite Har-
warden (L. H. P.).

A. Ludoviciana Nutt.

Sioux City (L. H. P.).

A. biennis Willd.

Sioux City (B. W.).

Senecio aureus L.

Sioux City (B. W.).

Cacalia tuberosa Nutt.

Council Bluffs (L. H. P.); Smithland (B. W.).

Arctium Lappa L.

Sioux City (B. W.).

Cnicus undulatus Gray.

Sioux City, lower parts of loess mounds; abundant in places
(L. H. P.).

C. altissimus Willd. var. *filipendulus* Gray.

Has been sent to me from western Iowa—Ruthven (D. Cha-
pin); Sioux City (L. H. P.; Hitchcock Bot. Gazette, XIV,

129). This approaches *C. undulatus*, Miss Wakefield's *C. undulatus*, from Sioux City, is referable to this variety.

Var. *discolor* Gray.

Sioux City (B. W.).

C. arvensis Hoffm.

Maple River Junction (Bernholtz).

Krigia Dandelion Nutt.

Sioux City (B. W.).

Lygodesmia juncea Don.

Sioux City, loess mounds very abundant (L. H. P.); Logan, Missouri Valley, Turin (L. H. P.); Hull, weedy (James C. Watson); Little Rock, weedy (C. R. Ball); Battle Creek, roadsides, weedy (E. G. Preston). Very abundant tops and sides of mounds. In August and September most of the plants are affected with galls.

Taraxacum officinale Weber.

Sioux City (B. W.).

Lactuca Scariola L.

Missouri Valley (L. H. P.). Common in streets of Council Bluffs, Onawa, Turin (L. H. P. observations).

L. Canadensis L.

Sioux City (B. W.).

L. integrifolia Bigel.

Lake Okoboji (B. W.).

L. pulchella Bigel.

Sioux City, base of loess mounds and in streets (B. W., L. H. P.).

LOBELIACEÆ.

Lobelia syphilitica L.

Sioux City (B. W.).

L. spicata Lam.

Rock Valley (C. R. Ball), Sioux City (B. W.).

CAMPANULACEÆ.

Campanula Americana L.

Sioux City (B. W.), Hull (W. Newell).

ERICACEÆ.

Monotropa uniflora L.

Smithland, in rich woods (B. W.).

PRIMULACEÆ.

Steironema ciliatum Raf.

Rock Valley (J. Jensen and W. Newell), Sioux City (B. W.).

S. lanceolatum Gray.

Little Rock (C. R. Ball).

APOCYNACEÆ.

Apocynum cannabinum L.

Little Rock (C. R. Ball), Sioux City (B. W.).

ASCLEPIADACEÆ.

Asclepias tuberosa L.

Hull (W. Newell), Sioux City (B. W.).

A. incarnata L.

Hull (W. Newell), Sioux City (B. W.).

A. Cornuti Decaisne.

Sioux City (B. W.), Little Rock (C. R. Ball).

A. ovalifolia Decaisne.

Sioux City (B. W.).

A. verticillata L.

Sioux City, loess mounds, common in open places (B. W., L. H. P.); South Dakota, opposite Hawarden, hills; Turin, Missouri Valley (L. H. P.); Rock Valley (J. F. Jensen and W. Newell).

Acerates virdiflora Ell.

Little Rock (C. R. Ball).

GENTIANACEÆ.

Gentiana puberula Michx.

Sioux City, grassy low lands and hills; not common (B. W.).

G. Andrewsii Griseb.

Sioux City, meadows of Missouri river bottom (B. W.).

POLEMONIACEÆ.

Phlox pilosa L.

Sioux City (B. W.); Little Rock (C. R. Ball).

P. divaricata L.

Sioux City, in rich woods (B. W.).

Polemonium reptans L.

Cherokee, in rich woods (B. W.).

BORRAGINACEÆ.

Echinosperrum Virginicum Lehm.

Sioux City, woods, along streets and roadsides (B. W.).

Lithospermum canescens Lehm.

Sioux City, prairies, and loess mounds (B. W.)

L. angustifolium Michx.

Sioux City, prairie and loess mounds (B. W.).

Onosmodium Carolinianum D. C. var. *molle*, Gray.

Sioux City, prairies and common on loess mounds (B. W.);
Little Rock (C. R. Ball); Council Bluffs, loess woods,
South Dakota opposite Hawarden, border of woods,
hills (L. H. P.).

CONVOLVULACEÆ.

Convolvulus sepium L.

Sioux City (B. B.); a common weed in fields, and pastures,
gardens and meadows (L. H. P. observations).

Cuscuta glomerata Choisy.

Sioux City on *Helianthus*, *Solidago*, common (B. W.).

SOLANACEÆ.

Solanum nigrum L.

Sioux City (B. W.).

S. Carolinense L.

Introduced; Mapleton (Abjah Lamb); Logan, along road-
sides, Council Bluffs in streets (L. H. P.).

S. rostratum Dunal.

Woodbine; South Dakota, opposite Hawarden (L. H. P.).

Physalis pubescens L.

Sioux City B. W.); A very common weed in neglected yards
Missouri Valley, Council Bluffs, Osawa (L. H. P. observations).

SCROPHULARIACEÆ.

Scrophularia nodosa L. var. *Marilandica* Gray.

Sioux City (B. W.); Little Rock (C. R. Ball).

Pentstemon grandiflorus Nutt.

Sioux City, common on the sides of the loess mounds (L.
H. P., B. W.).

Mimulus ringens L.

Sioux City in low grounds (B. W.).

Ilysanthes riparia Raf.

Sioux City, low grounds and muddy places (B. W.);
Hawarden (L. H. P.); Hull (W. Newell).

Veronica Virginica L.

Sioux City (B. W.); Hull (W. Newell); Little Rock (C. R.
Ball).

Gerardia aspera Dougl.

Sioux City, common on sides and tops of loess mounds (L.
H. P.).

G. tenuifolia Vahl.

Missouri Valley, loess mounds (L. H. P.).

Castilleja sessiliflora Pursh.

Sioux City, abundant on loess mounds (B. W.).

LENTIBULARIACEÆ.

Utricularia vulgaris L.

Hull (W. Newell).

PEDALIACEÆ.

Martynia proboscidea Glox.

Missouri Valley, in fields, base of hills (L. H. P.).

VERBENACEÆ.

Verbena urticifolia L.

Sioux City (B. W.); Hull (W. Newell); Turin, Missouri Valley, low grounds (L. H. P.).

V. hastata L.

Sioux City, fields and low ground (B. W.); Hull (W. Newell).

V. stricta Vent.

Sioux City, base of loess mounds, prairies and fields, abundant (B. W.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Turin, Missouri Valley (L. H. P.).

Phryma leptostachya L.

Sioux City (B. W.).

LABIATÆ.

Teucrium Canadense L.

Sioux City, low grounds, abundant (B. W.); Council Bluffs, abundant (L. H. P.).

Mentha Canadensis L.

Sioux City (B. W.); Hull (W. Newell); Little Rock, low grounds (C. R. Ball).

Lycopus sinutus Ell.

Sioux City (B. W.); Hull, low grounds (W. Newell).

L. Virginicus L.

Sioux City (B. W.).

Hedeoma hispida, Pursh.

Sioux City (B. W.).

Pycnanthemum lanceolatum Pursh.

Spirit Lake (B. W.).

Salvia lanceolata Willd.

Council Bluffs (L. H. P. observations).

Monarda fistulosa L.

Logan, prairies and borders of woods (L. H. P.).

Lophanthus scrophulariæfolius Benth.

Sioux City (B. W.).

Nepeta Cataria L.

Sioux City (B. W.). A common weed in western Iowa (L. H. P.).

Scutellaria lateriflora L.

Turin, rich, low woods near stream (L. H. P.); Sioux City (B. W.).

S. parvula Michx.

Little Rock (C. R. Ball); Sioux City (B. W.).

Physostegia Virginiana Benth.

Sioux City, low grounds (B. W.).

Stachys palustris L.

Sioux City, low grounds (B. W.); Rock Valley (J. Jensen, W. Newell).

PLANTAGINACEÆ.

Plantago major L.

Sioux City (B. W.).

P. Patagonica Jacq., var. *gnaphalioides* Gray.

Rock Valley (J. Jensen, W. Newell).

NYCTAGINACEÆ.

Oxybaphus hirsutus Sweet.

Hull (W. Newell); Sioux City, common along roadsides and fields (B. W.); Little Rock (C. R. Ball).

O. angustifolius Sweet.

Sioux City, loess hills near top (L. H. P.).

AMARANTACEÆ.

A. retroflexus L.

A common weed everywhere in western Iowa (L. H. P.); Sioux City (B. W.).

A. albus L.

Sioux City (B. W.); Onawa, Turin, a common weed (L. H. P.).

A. blitoides Watson.

Sioux City, loess mounds in open places (L. H. P.).

Acnida tuberculata Mcq.

Onawa, common weed in cultivated ground (L. H. P.).

CHENOPODIACEÆ.

Onawa, Turin, Des Moines (L. H. P.); Smithland (J. M. Wrapp); Sioux City (B. W.).

C. urbicum L.

Onawa, Missouri Valley, Turin near stables and houses (L. H. P.).

C. hybridum L.

Missouri Valley, Turin, Onawa (L. H. P.); Sioux City (B. W.), a common weed in waste places.

Salsola Kali L., var. *tragus* Moq.

Onawa, Sioux City, Missouri Valley, Hawarden, Council Bluffs (L. H. P.), spreading rapidly.

POLYGONACEAE.

Rumex verticillatus L.

Missouri Valley, in swamps, common (L. H. P.).

R. crispus L.

Council Bluffs, weed in streets (L. H. P. observations).

R. maritimum L.

Sioux City (B. W.); Little Rock (C. R. Ball), in low grounds.

R. Acetosella L.

Missouri Valley, Turin, weedy in yards and fields (L. H. P.).

Polygonum aviculare L.

Sioux City (B. W.); Hawarden, weed in yards (L. H. P.); Missouri Valley.

P. erectum L.

Missouri Valley, common weed in streets (L. H. P.).

P. ramosissimum Michx.

Missouri Valley, Sioux City, L. H. P., B. W.) Hawarden (L. H. P.).

P. lapathifolium L., var. *incarnatum* Watson.

Sioux City, (B. W.); Turin, low grounds (L. H. P.).

P. Pennsylvanicum L.

Logan, Turin, Onawa, Missouri Valley, low grounds, (L. H. P.); Hull (N. Newell).

P. Muhlenbergii Watson.

Sioux City (B. W.), common along the Missouri river (L. H. P.).

P. Persicaria L.

Hull (W. Newell); Sioux City (B. W.).

P. orientale L.

Missouri Valley, an escape from cultivation (L. H. P.).

P. acre HBK.

Hull (W. Newell).

P. Virginianum L.

Sioux City (B. W.).

P. Convolvulus L.

Sioux City (B. W.), Hull (W. Newell).

P. dumetorum L., var. *scandens* Gray.

Sioux City (B. W.).

ARISTOLOCHIACEÆ.

Asarum Canadense L.

Cherokee (B. W.).

ELÆAGNACEÆ.

Shepherdia argentea Nutt.

Sioux City, sandy banks of Missouri river (B. W., L. H.

P., Hitchcock, Bot. Gazette, XIV, 128).

EUPHORBIACEÆ.

Euphorbia maculata L.

Missouri Valley, Des Moines, Turin and Onawa; waste places and along railroad (L. H. P.).

E. hypericifolia.

Onawa (L. H. P.), Sioux City (B. W.).

E. marginata Pursh.

South Dakota, opposite Hawarden, hills, Missouri Valley, Turin and in waste places (L. H. P.), Hull (W. Newell), Council Bluffs (L. H. P.), Sioux City (B. W., L. H. P.).

E. corollata L.

Missouri Valley (L. H. P.), Sioux City (B. W.).

E. serpens H. B. K.

Missouri Valley, low grounds (L. H. P.).

E. serpyllifolia Pers.

Turin (L. H. P.), Sioux City (B. W.).

Var. *consanguinea*.

Onawa, Turin (L. H. P.).

E. glyptosperma Engelm.

Missouri Valley (L. H. P.).

Var. *pubescens*.

Turin (L. H. P.).

E. hexagona Nutt.

Missouri Valley (L. H. P.), Sioux City (B. W.).

E. Geyeri Engelm.

Missouri Valley (L. H. P.)

E. heterophylla L.

Sioux City, in woods, Council Bluffs (L. H. P.); Sioux City (B. W.).

E. obtusata Push.

Sioux City (B. W.).

Acalypha Virginica L.

Sioux City (B. W.)

URTICACEÆ.

Ulmus fulva Michx.

Sioux City, in valleys between loess mounds (B. W., L. H. P.); South Dakota opposite Hawarden.

U. Americana L.

Sioux City, along the Big Sioux river and Missouri river (B. W., L. H. P.).

Celtis occidentalis L.

Sioux City, along Missouri and Big Sioux rivers (L. H. P.).

Cannabis sativa L.

Missouri Valley (L. H. P. observations); Sioux City (B. W.).

Humulus Lupulus L.

Sioux City (B. W.).

Urtica gracilis Ait.

Sioux City (B. W.); Little Rock (Herb. C. R. Ball.).

Laportea Canadensis Gaudichaud.

Sioux City (B. W.).

Pilea pumila Gray.

Logan (L. H. P.)

Parietaria Pennsylvanica Muhl.

Turin (L. H. P.).

JUGLANDACEÆ.

Juglans nigra L.

Sioux City (B. W.).

Carya olivæformis Nutt.

Sioux City (Hitchcock); this is further north than it occurs elsewhere in this state.

C. amara Nutt.

Smithland (B. W.).

CUPULIFERÆ.

Corylus Americana Walt.

Sioux City (B. W.).

Ostrya Virginica Willd.

Council Bluffs, in woods, back of steep mounds (L. H. P.); Logan (L. H. P.); Sioux City (B. W.).

Quercus macrocarpa Michx.

Council Bluffs (L. H. P.).

Var. *olivæformis* Gray.

Sioux City, sides of bluffs (L. H. P., B. W.)

Q. rubra L.

Sioux City (B. W.).

SALICACEÆ.

Salix humilis Marsh.

Sioux City, common on prairies and at base of loess mounds (L. H. P.).

S. longifolia Muhl.

Sioux City (B. W.).

Populus monilifera Ait.

Missouri Valley, in bottoms near streams, in swales between loess mounds; occasionally near top of mound. Common (L. H. P.), South Dakota, opposite Hawarden (L. H. P.); Sioux City (B. W.).

CERATOPHYLLACEÆ.

Ceratophyllum demersum L.

Sioux City (B. W.).

CONIFERÆ.

Juniperus Virginiana L.

Sioux City (B. W.).

ORCHIDACEÆ.

Orchis spectabilis L.

Sioux City (B. W.).

Habenaria leucophæa Gray.

Cherokee (B. W.).

Spiranthes cernua Richard.

Smithland (B. W.).

Cypripedium pubescens Willd.

Cherokee, Smithland (B. W.).

IRIDIACEÆ.

Iris versicolor L.

Sioux City (B. W.).

LILIACEÆ.

Smilax herbacea D.

Sioux City (B. W.).

Allium stellatum Fras.

Alton, common on prairies (L. H. P.).

A. Canadense Kalm.

Sioux City (B. W.).

Yucca angustifolia Pursh.

Council Bluffs, Missouri Valley, Sioux City, Turin (L. H. P.); near top of loess, mounds common. South, north and west sides. Many seeds produced. Not all the plants which flower produce seeds—many empty stalks were found. It is a significant fact that this species does

not occur on the east slopes of the mounds, perhaps because they are more or less wooded about Council Bluffs and Missouri Valley. Sioux City (B. W.), Hitchcock Bot. Gazette, XIV, p. 128.

Polygonatum giganteum Dietr.

Sioux City (B. W., L. H. P. observations). Deep rich woods.

Smilacina stellata Desf.

Sioux City (B. W.).

Uvularia grandiflora Smith.

Sioux City (B. W.).

Erythronium albidum Nutt.

Sioux City (B. W.).

Lilium Philadelphicum L.

Little Rock (Herb., C. R. Ball).

L. Canadense L.

Sioux City (B. W.).

Trillium nivale Riddell.

Cherokee (B. W.).

Zygadenus elegans Pursh.

Little Rock (Herb., C. R. Ball).

COMMELINACEÆ.

Tradescantia Virginica L.

Sioux City (B. W.).

JUNCACEÆ.

Juncus tenuis Willd.

Sioux City (B. W., L. H. P. observations).

J. nodosus.

Sioux City (B. W.).

TYPHACEÆ.

Typha latifolia L.

Sioux City (B. W.).

Sparganium eurycarpum Engelm.

ARACEÆ.

Dickinson Co. (Hitchcock); Hull (W. Newell).

Arisaema triphyllum Torr.

Sioux City (B. W.).

ALISMACEÆ.

Alisma plantago L.

Sioux City (B. W.).

Echinodorus rostratus Nutt.

Sioux City, Big Sioux river (L. H. P.).

NAIADACEÆ.

Potamogeton natans L.

Lake Okoboji (Hitchcock).

P. lonchites Tuck.

Spirit Lake (Hitchcock).

P. praelongus Wulf.

Clear Lake (Hitchcock).

P. perfoliatus L. var. *Richardsonii*, Bennett.

Lake Okoboji and Spirit Lake (Hitchcock).

P. zosterifolius Schum.

Lake Okoboji (Hitchcock).

P. mucronatus Schrad.

Spirit Lake (Hitchcock).

P. pectinatus L.

Woodbine (Burgess); Lake Okoboji (Hitchcock)

CYPERACEÆ.

Cyperus diandrus Torr.

Near Lake Okoboji (B. W.).

C. Schweinitzii Torr.

Lake Okoboji (B. W.).

Eleocharis acicularis R. Br.

Sioux City (B. W.; L. H. P.).

Scirpus lacustris L.

Council Bluffs (L. H. P. observations); Sioux City (B. W.).

S. atrovirens Muhl.

Sioux City (B. W.).

Species of *Carex* numerous, but omitted because they have not been studied critically. There are also a large number of grasses, localities and species will appear in another connection.

SOME NOTES ON CHROMOGENIC BACTERIA.

L. H. PAMMEL AND ROBERT COMBS.

Quite a large list of chromogenic bacteria are known to bacteriologists. Many of these are familiar objects in bacteriological laboratories. Of the early works describing these in this country we may mention Sternberg and Trelease. For later works on North American chromogenic bacteria we must refer to Sternberg, Jordan and the numerous text books dealing with pathogenic species.

Very few attempts have been made to study our local bacteriological floras. It is indeed a very difficult matter.

The following works describe Chromogenes:

Saccardo: Sylloge Fungorum VIII.

Sternberg: Manual of Bacteriology. 1892.

Trelease: Observations on several Zoogloea (Studies Biol. Lab. of the Johns Hopkins University). 1885.

P. & G. C. Frankland: Micro-organisms in Water. 1894.

Adametz: Die Bakterien der Trink-und Nutzwasser. Mitth. der Oester Versuchstation fur Brauerei-und Malzerei in Wien, 1888. Heft 1.

Jordan: A report on certain species of bacteria observed in sewage. Rep. Mass. State Board of Health, 1888-1890, plate II.

Eisenberg: Bakteriologische Diagnostik. 1888.

Welz: Bakteriologische Untersuchungen der Freiburger Luft, Zeitschrift fur Hygiene XI, p. 121.

No attempt will be made to give description of common species found here at Ames, simply a record of their occurrence including some laboratory observations.

Micrococcus cyanogenus. N. SP.

Source.—During the latter part of May, 1894, a foreign blue color was observed on an old milk culture of an organism obtained from cheese; later the same was found in an old milk culture of *Bacillus aromaticus*. A transfer from the first milk tube was made to another tube of sterilized milk, the typical color appearing in three or four days. The organism was separated by pouring plates of agar.

Morphology.—A small micrococcus occurring singly or in groups; motility not determined. An aerobic liquefying micrococcus.

Agar.—Nearly colorless, with a slight tinge of blue, producing an irregular film on surface, growing at temperature of room.

Gelatin.—A creamy white layer not spreading on surface, soon liquefying, forming a funnel-shaped area, later the medium was liquefied with a creamy white sediment in the bottom of the tube.

Milk.—Sterilized milk inoculated produces in three days a slight blue layer on surface, which increases in intensity, becoming quite blue for one-third of an inch on the seventh day. On the eighth day it appeared rather muddy; on the ninth day only a faint blue color remained; it coagulated milk with a

blue liquid on top. The curd was dissolved slowly. In twenty-five days the process was completed, excepting a small portion in the bottom of the flask.

Dunham's peptone solution.—No color produced; the medium became cloudy, which was in no way characteristic. It failed to grow in Dunham's rosalic acid solution.

Several blue organisms have been described.

Bacillus cyanogenus is a well known inhabitant of milk. This is a non-liquefying, actively motile bacillus. Has not been found here at Ames. Gessard has shown that in presence of an acid it produces an intense blue color, and in milk not sterilized containing lactic acid germs, a sky blue color is produced.

Jordan has also described a *Bacillus cyanogenus*, which is less motile forming a deep brown color on potato, but he says undoubtedly *Bacillus cyanogenus*. Beyerinck² has also described a blue organism obtained from cheese, the *Bacillus cyaneo-fuscus*. The original paper has not been seen but according to the description given by Sternberg this is a small bacillus 0.2-0.6 u. long and one half as thick. It is an aerobic liquefying motile bacillus, and when cultivated in a solution containing one-half per cent of peptone the culture media acquires at first a green color, which later changes to blue, brown and black. Subsequently the color is entirely lost. More recently Wm. Zangemeister³ has described a bacillus cyaneo-fluorescens.

This species is in many respects similar to *Bacillus cyanogenus*.

It is however somewhat shorter and very actively motile.

Gelatin is not liquefied and the bright greenish fluorescent pigment diffuses through it.

Our species also came from cheese and the blue color disappears, but the organism in question never produces a black color. The species so far as we have been able to determine is new, and we have therefore given it the name of *Micrococcus cyanogenus*.

Staphylococcus pyogenes, Ogston var. *aureus* Rosenbach.—This, the most common of the pyogenic micrococci has been found quite frequently here at Ames. It has at different times been isolated from ordinary carbuncle, fistula, dirt under the finger nails, etc. It has been found more commonly in suppurative abscesses than any other organism. It is pathogenic to mice

²Sternberg: Manual of Bacteriology p. 727.

³Kurze Mittheilungen über Bakterien der-blauen Milch. Centralblatt f. Bakt. u. Parasitenkunde. Erste Abt., XVIII, p. 321.

and rats. Old cultures, however, soon lose their virulence. A culture nine months old failed to cause any lesions in mice, not even the local formation of pus.

St. pyogenes, Ogston var. *citreus* Passet.—This species has not been found spontaneously in any of the cases of pus studied, though it has been cultivated in the laboratory. It has been included with the pyogenic cocci because of its occurrence in pus. Passet found the organism in the pus of an acute abscess and Sternberg⁴ says: "As to its pathogenic properties, we have no definite information. It is included among the pyogenic bacteria because of occasional presence in the pus of acute abscesses, although it has heretofore only been found in association with other micro-organisms." Mice have been inoculated here at Ames but in no case did fatal septicæmia follow. We have, however, had no trouble in obtaining pus at the point of inoculation under the root of the tail. From this pus, pure cultures of the organisms were obtained.

St. pyogenes Ogston var., *flavescens* Trev.—Obtained from the fistula of a horse by Dr. S. Whitbeck in bacteriological laboratory, Iowa Agricultural college. This organism does not differ from the foregoing in size; in color, however, it is much paler, being an ochre yellow. It produces fatal septicæmia in mice when fresh cultures were used, but in this case pure cultures were not obtained.

Streptococcus cinnabareus, Flügge.—Obtained at first from butter, but probably came either from the air or water. Color in different media is quite constant, except in blood serum, where its color is much paler. It grows quite characteristic on the surface of bouillon, forming spherical masses paler than in agar or potato. A nearly related species was isolated by Dr. W. B. Niles from the heart of a diseased steer affected with corn-stalk disease. It differs from the *cinnabareus* in the change of color. It is dark lemon-yellow at first, and then changes to a brick-red. This species will be described in another connection.

Sarcina lutea Schröter.—This well known organism occurs chiefly in the air. Gelatin and agar plates exposed to the air invariably show this organism. It comes up somewhat more tardily than the non-chromogenic species. They appear as small, yellow, spherical colonies. The canary-yellow growth liquefies gelatin quite slowly. The same organism has been

⁴Manual of Bacteriology p. 273.

obtained frequently from butter and milk, but the organism undoubtedly came from the air.

S. aurantiaca Flügge.—This organism is also quite commonly met, and appears on gelatin and agar plates exposed to the air.

Bacillus fluorescens liqae faciens Flügge.—This common inhabitant of water also occurs on potato, milk and butter. Scarcely a sample of water can be plated without obtaining this organism.

B. pyocyaneus Gessard.—This has been obtained several times from wounds and Dr. S. Whitbeck obtained a pure culture in open synovial bursa. Inoculation into the peritoneal cavity was followed by death in forty-eight hours. In old cultures there is a gradual tendency for the organism to lose its power of forming coloring matter. Gessard⁵ has isolated two pigments a fluorescent green and a blue, the latter called pycocyanin.

Bacillus prodigiosus Ehrenberg.—This species is well known to most bacteriologists. It has long attracted attention because of the red stains produced on potatoes, boiled bread, and the red color it imparts to milk. According to several investigators this organism is not a native to this country.

The species is however, recorded at Ames by Bessey. He commonly obtained a red organism on sliced potatoes exposed to the air.

There are of course several red organisms and as the organism was reported before the era of modern bacteriological methods I must therefore express some doubt as to the correct determination of the *Bacillus prodigiosus* found by Bessey. The senior writer has at various times had cultures of this organism in the laboratory. Thus we had good growing cultures in 1889, 1892, but all attempts to make old cultures failed. In 1894 a blood-red colony came up in culture plate. Cultures of this organism had never been in this laboratory so far as we know. In the spring we had received from Dr. Irving W. Smith, cultures of several species obtained from the laboratory of Johns Hopkins University. The cultures appeared pure but they may have been contaminated. The senior writer observed this organism on one other occasion in the botanical laboratory of the Shaw School of Botany, St. Louis. Cultures of *B. prodigiosus* were obtained from rotting sweet potatoes, but European cultures were common at the time in the labora-

⁵Gessard. De la pyocyanine et de son Microbe. These de Paris, 1882. Nouvelles recherches sur la Microbe pyocyanique. Ann. d l'Institut Pasteur. Vol. IV, 1890, p. 89

⁶Bull. Dept. of Botany, Nov. 1884.

tory. Professor Trelease thought it probable that the species came from the European cultures. We are therefore inclined to believe with Jordan, Russell, and others that the species is not native in this country.

FUNGUS DISEASES OF PLANTS AT AMES, IOWA, 1895.

BY L. H. PAMMEL AND GEO. W. CARVER.

In previous papers record has been made of the abundance of parasitic fungi for the years of 1891, 1892, 1893 and 1894.¹ We hope to continue these observations for the purpose of making comparison.

Observations from year to year with climatic conditions should make it possible to say how much climate modifies the appearance of disease. Observations in a climate like ours are valuable because of the changeable conditions as to humidity and rainfall. From the nature of the diseases of plants it is difficult to make exact statements. We must speak in relative terms. In 1893 *Puccinia graminis*, *P. rubigo-vera* and *P. coronata* were very destructive. In 1894 these rusts were not absent, but they were not destructive; in fact, scarce as compared with 1893.

In the study of diseases of plants the condition of the atmosphere with reference to moisture is an important factor. The universally low humidity of the atmosphere in 1894, no doubt, largely determined the amount of rust that year. So low was the humidity that during the growing season dew was an unusual condition.

We append table, giving rainfall, relative humidity, 7 A. M. temperature (maximum and minimum), for the months of May, June, July, August and September, taken from the records made at Ames by Dr. J. B. Weems, Mr. W. H. Heileman.

¹ L. H. Pammel, Jour. Mycology, VII, p. 95.

Agricultural Science, VII, p. 29.

Proc. Iowa Academy of Science, II, p. 201-203

MAY.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall.....	.08	.30	.38	.....	.02	1.18	.....	.....	.....	.11	.....	.....	.....	.....	.17	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rel. hum. 7:00 a. m. ....	.76	.75	.85	.80	.73	.79	.89	.89	.93	.64	.63	.63	.53	.53	.60	.59	.69	.64	.63	.62	.67	.72	.77	.80	.69	.74	.86	.93	.88	.88	.86
Temperature-max.	60	59	56	61	59	56	56	52	61	44	37	29	38	31	43	39	42	47	35	36	31	32	40	40	57	40	40	69	72	70	66
Temperature-min.																															

JUNE.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall.....	.....	1.06	.08	.....	.....	.....	.12	.....	.36	.44	.....	.....	.40	.39	.....	.47	.....	.....	.....	.....	.....	.43	.24	.44	.03	.20	.....	.....	.....	.....	.....
Rel. hum. 7:00 a. m. ....	.95	.78	.78	.76	.71	.78	.79	.71	.63	.95	.99	.91	.84	.91	.71	.74	.90	.78	.70	.85	.75	.85	.90	.86	.69	.79	.89	.77	.83	.75	.....
Temperature-max.	90	85	83	68	77	84	84	88	86	69	77	81	81	81	85	84	80	76	80	85	80	81	84	88	74	74	72	69	74	81	.....
Temperature-min.	67	64	50	48	49	60	57	63	61	63	55	51	53	56	60	62	57	50	53	57	54	61	60	65	57	49	49	50	56	54	.....

JULY.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.18	.22	.....	.32	.....	.....	.80	.....	.....	.....	.....	.29	.....	.38	.09	.....	.....	.....
Rel. hum. 7:00 a. m. ....	.85	.90	.85	.80	.86	.86	.66	.77	.71	.83	.65	.71	.91	.95	.95	.95	.72	.95	.95	.99	.99	.89	.90	.90	.95	.95	.94	.85	.90	.95	.99
Temperature-max.	86	85	85	85	86	93	85	65	72	80	84	88	81	89	88	93	89	92	86	82	74	70	79	85	80	89	81	85	81	74	80
Temperature-min.	60	56	63	67	64	53	54	41	46	56	54	53	52	58	52	65	66	66	62	60	57	55	56	57	62	62	62	63	58	49	52

AUGUST.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall.....	.....	.06	.07	T	.....	.....	.....	.....	.64	.....	.....	.....	.....	.....	.....	T	.....	.....	.....	.....	.....	1.92	.74	.....	.05	.....	1.35	T	.....	1	.....
Rel. hum. 7:00 a. m. ....	.84	.81	.74	.69	.90	.80	.67	.81	.71	.99	.78	.84	.80	.85	.69	.90	.85	.60	.88	.72	.84	.85	.95	.95	.81	.95	.99	.99	.84	.94	.76
Temperature-max.	85	87	85	85	80	82	80	94	93	85	88	91	84	84	88	94	81	71	77	84	85	93	71	84	81	87	94	74	79	83	68
Temperature-min.	61	56	63	57	60	55	65	71	67	60	55	58	62	57	62	64	51	52	48	50	59	66	63	59	67	67	65	57	50	52	44

SEPTEMBER.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall.....	.....	.....	.....	.....	.32	.....	.....	.....	.....	.....	.....	.....	.52	.....	.96	.....	.....	.....	.....	1.32	.....	.66	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rel. hum. 7:00 a. m. ....	.68	.89	.82	.65	.95	.85	.67	.61	.95	.82	.82	.81	.94	.78	.87	.95	.95	.76	.74	.66	.74	.82	.85	.73	.94	.65	.77	.66	.70	.60	.....
Temperature-max.	77	78	89	89	90	78	67	78	86	67	93	87	78	81	98	87	93	92	90	88	88	88	65	72	78	66	.65	.60	.55	.60	.....
Temperature-min.	51	53	57	57	57	45	43	61	66	73	62	60	58	59	62	64	67	68	73	64	63	26	42	48	46	38	41	37	30	31	.....

We have followed Saccardo (Sylloge Fungorum) in the arrangement of orders, genera and species, and in most cases have used the synonymy given by him.

USTILAGINEAE.

Ustilago hypodytes (Schlecht.) Fr.

Very abundant. On *Stipa spartea*.

U. tritici (Pers.) Jensen.

Not uncommon and was frequent in 1894 on *Triticum vulgare*.

U. hordei (Pers.) Kellerman and Swingle.

Common on *Hordeum vulgare*.

U. nuda (Jensen) Kellerman and Swingle.

Scarce on *Hordeum vulgare*.

U. avenae (Pers.) Jensen.

Not uncommon on *Avena sativa*.

U. segetum (Bull) Dittm.

Common on *Arrhenatherum avenaceum*.

U. neglecta Niessl.

Abundant on *Setaria glauca*.

U. Rabenhorstiana Kuhn.

On *Panicum sanguinale* abundant.

U. maydis (D. C.) Corda.

Abundant on *Zea mays*.

U. pustulata Tracy & Earle.

Locally abundant in one place, first time observed on *Panicum proliferum*.

Tilletia-striceformis (Westend.) Magnus.

Not abundant on *Phleum pratense*.

T. foetens (B. & C.) Trelease.

Not observed in 1895.

Schizonella melanogramma (D. C.) Schroet.

Abundant in May, Moingona.

Sorosporium syntherismae (Schw.) Farlow.

Abundant on *Panicum capillare*.

Urocystis Agropyri (Preuss) Schroet.

Abundant in June and early July on *Elymus Canadensis*.

UREDINEÆ.

Uromyces Polygoni (Pers.) Fuckel.

Abundant August and September on *Polygonum aviculare* and *P. erectum*.

U. Trifolii (Hedw.) Lev.

Abundant in September on *Trifolium pratense*. This fungus has been increasing in severity, large patches of second crop of clover being affected.

U. appendiculatus (Pers.) Link.

Abundant on *Strophostyles angulosa*, but not observed here on *Phaseolus vulgaris*. At Indianola it was, however, destructive to the cultivated bean.

U. Euphorbice Cooke & Peck.

Abundant in August and July on *Euphorbia maculata* and *E. Preslii*.

Melampsora farinosa (Pers.) Schroet.

Abundant on *Salix*, August and September.

M. Populina (Jacq.) Lev.

Abundant on *Populus monilifera*, August and September.

Puccinia Helianthi Schw.

Abundant on *Helianthus tuberosus* and *H. grosse-serratus* July, August and September. In August especially destructive to cultivated *Helianthus annuus*.

P. Convolvuli (Pers.) Cast.

Abundant on *Convolvulus sepium* July, August and September.

Gymnosporangium macropus Link.

Teleuto stage on *Juniperus Virginiana* not as abundant as in 1894; nor was the æcidium (*Roestelia pyrata*) so abundant on *Pyrus Iowensis*. Locally, however, in Madison county it seriously affected the leaves, stems and fruit of the wild crab. May was unfavorable for the germination and development of the teleutospores.

Phragmidium subcorticium (Schränk.) Winter.

Abundant on the leaves of the cultivated rose, as Madam Charles, Frederick Worth, August and September.

Æcidium Grossulariæ Schum.

Not so common as in 1894 on *Ribes Grossulariæ*, *R. gracile*.

Uredo Caeoma-nitens Schw.

(*C. interstitiale*, Schlecht and is supposed to be connected with *Puccinia Peckiana*.) Abundant on *Rubus villosus*; large patches of native blackberry destroyed; seriously affecting cultivated blackberry locally. It was also observed in Story, Polk, Louisa and Henry counties.

P. Graminis Pers.

Not common on *Triticum vulgare*, *Avena sativa* and *Hordeum jubatum*. June and July. *Aecidium* abundant on *Berberis vulgaris* May-June. Very destructive on fall sown oats and wheat. August and September; also *Hordeum jubatum*.

P. coronata Corda.

Not common on *Avena sativa*, June and July. Abundant August and September. Klebahn has recently separated another species out of what has passed as this, until further work in this country, the species is used here as it is by American authors generally.

P. rubigo-vera (D. C.) Wint.

Not common, on wheat June and July. Abundant on fall sown wheat, *Hordeum jubatum*, August and September. Squirrel-tail grass is held in check by this fungus.

P. Sorghi Schw.

Abundant August and September on *Zea Mays*.

P. emaculata Schw.

Abundant on *Panicum capillare* August and September.

P. Andropogonis Schw.

Not abundant on *Andropogon furcatus*. *A. scoparius*, August and September.

P. Xanthii Schw.

Abundant on *Xanthium Canadense*, July, August and September. In low grounds destroyed a large number of plants.

PERONOSPORACEÆ.

Cystopus candidus (Pers.). Lev.

Abundant early in the season on *Lepidium intermedium*, *L. Virginicum*, *Capsella bursa-pastoris*. Later, oospores abundant in inflorescence of *Rhaphanus sativa*.

C. Tragopogonis (Pers.) Schroet.

Locally abundant in June and early July.

C. Portulacæ (D. C.) Lev.

Abundant on *Portulaca oleracea* from the middle of June to the first of September. Oospores abundant.

C. Bliti (Biv.) De By.

Abundant July, August and September on *Amarantus albus*, *A. retroflexus*. More severe on the latter species.

Sclerospora graminicola (Sacc.) Schroet.

Abundant during the latter part of May till middle of June,

destroying large numbers of young plants of *Setaria viridis*. In whole patches it prevented the maturing of seeds.

Plasmopara Viticola (B. and C.) B. and DeT.

Abundant. Destructive to cultivated grape (*Vitis Labrusca*), affecting leaf, stem and fruit. Also affecting the growing of young shoots of *Vitis riparia*, in some cases killing the young shoots.

P. Halstedii (Farlow) B. and DeT.

Not common, on *Helianthus annuus*, *H. tuberosus*, *Silphium laciniatum*, *Xanthium Canadense*, *Centaurea*.

Bremia Lactuce Regel.

Not observed although abundant in 1893.

Peronospora Viciae (Berk.) DeBy.

Abundant in latter part of May and early June on *Vicia Americana*.

P. Arthuri Farlow.

Abundant on *Oenothera biennis*.

P. parasitica (Pers.) DeBy.

Abundant on leaves and stems of *Lepidium intermedia*, *L. Virginicum*, killing the affected plants. On leaves of *Capsella bursa pastoris* not destructive. *Brassica nigra*, *B. campestris*, *Raphanus sativa*, *Draba Caroliniana*. *Sisymbrium officinale* seriously affected.

P. Potentillae DeBy.

Not found in 1895. Local in 1894.

P. effusa (Grev) Rabenh.

Abundant on *Chenopodium album* in May and June.

P. Euphorbiae Fuck.

Locally abundant on *Euphorbia Preslii* and *E. maculata*.

P. alta Fuckel.

Abundant on *Plantago major*.

PERISPORIACEAE.

Podospheera Oxyacanthae (D. C.) De By.

Abundant on cultivated (*Prunus Cerasus*) and *P. pumila*.

Not common on *P. Americana*; also observed on young shoots of *Crataegus punctata*, and *C. mollis*; July, August and September.

Spærotheca Mali (Duby) Burrill.

Common on suckers of *Pyrus Malus* and young shoots of *P. toringo* in nursery, June, July and early August.

S. Mors-uvae (Schw.) Berk & Curt.

Abundant on *Ribes Grossulariae*, *R. floridum*, June, July; leaves, stem and fruit.

Phyllactinia suffulta (Reb.), Sacc.

Abundant on *Fraxinus Americana*, August and September.

Uncinula necator (Schw.) Burrill.

Common on *Vitis Labrusca*, Concord, Worden and especially Roger hybrids (Agawam).

Microsphaera Alni (D. C.) Wint.

Abundant on *Syringa vulgaris*, *S. Persica*, *Lonicera*, August and September. Abundant latter part of August and September.

Erysiphe Cichoracearum D. C.

Very abundant on *Helianthus annuus*, *H. tuberosus*. Not so common on *H. grosseserratus*. Abundant on *Ambrosia artemisiaefolia*, *A. trifida*, *Artemisia*, *Ludoviciana*; generally attacked by *Cicinnobulus Cesatii*. Abundant on *Verbena stricta*; less common on *V. hastata*.

E. communis (Wallr.) Schl.

Abundant on *Ranunculus abortivus* and *Amphicarpæa monoica*.

SPHÆRIACEÆ.

Physalospora Bidwellii (Ell.) Sacc.

None observed in 1895.

DOTHIDEACEÆ.

Phyllachora Graminis (Pers.) Fuck.

Common on *Muhlenbergia Mexicana*, *Elymus Canadensis*, *Panicum scoparium* *Asprella hystrix*.

P. Trifolii (Pers.) Fuck.

Abundant, conditial stage on *Trifolium pratense*, September.

Plowrightia morbosa (Schw.) Sacc.

Abundant on *Prunus domestica*, *P. Padus*, and wild *P. Americana*, *P. Virginiana* and Japan plum.

GYMNOASACEÆ.

Exoascus communis Sadebeck.

Rare on *Prunus Americana* in 1895; abundant on *Prunus Cerasus* and *P. domestica*. Nursery stock defoliated in August. Not as severe on *P. Americana*. Also occurred on *P. Mahaleb* and *P. avium*.

HYPHOMYCETÆ-MUCEDINEÆ.

Monilia fructigena Pers.

Abundant late in season on fruit of *Prunus Americana*.

DEMATIACEÆ.

Cladosporium carpophilum Thum.

Rare on *Prunus Americana*, but abundant on *Cratægus mollis* late in August and September.

Helminthosporium Graminum Rabh.

Not common on *Hordeum vulgare* in July.

Cercospora Resedæ Fuck.

Abundant on *Reseda odorata* in August and September.

C. Beticola Sacc.

Abundant on *Beta vulgaris*. (Sugar and mangel beets). September. In some cases leaves completely covered with cinereous spots.

C. angulata Winter.

Abundant on *Ribes rubrum*, shrubs nearly defoliated latter part of July and early August. Fungus appeared early in May.

SPHÆROPSIDEÆ SPHÆROIDACEÆ.

Septoria Rubi West.

Abundant on *Rubus odoratus*, *R. canadensis* August and September.

Septoria Ribis Desm.

Abundant on *Ribes nigrum*, June and September.

Melanconiaceæ.

Cylindrosporium Padi Karst.

Abundant on Cherry.

Marsonia Juglandis Sacc.

Trees of *Juglans cinerea* nearly defoliated by middle of August. Not so severe on *Juglans nigra*.

M. Martini Sacc.

Abundant on *Quercus robur*; majority of leaves affected; also occurred on *Q. macrocarpa*.

BACTERIACÆ.

Bacillus amylovorus (Burrill) Trev.

Blight more severe than in 1894. *Pyrus Malus*, *P. prunifolia*, *P. Sinensis*, *P. communis* and *P. Iowensis* especially severe on the following varieties of *P. Malus*: Yellow Transparent apple, Red Queen-Lead, Arabskoe Antonovka, Thaler, Oldenburg. It seems, also, to have been severe in other parts of the state. Fruiting orchards less affected than nursery stock. It would seem that the condition of the soil may influence the

severity of the disease. We should also observe that flowers are occasionally affected, but not so severe as in 1894. The disease gradually subsided by the middle of July and early August.

B. Sorghi W. A. Kellerman.

Not severe. It occurred on *Andropogon Sorghum* var *Halepense* and *A. Sorghum* (*Sorghum*).

B. cloaceae (Jordan).

On *Zea* mays; not abundant.

B. campestris Pammel.

Not observed in 1895.

SOME ANATOMICAL STUDIES OF THE LEAVES OF SPOROBULUS AND PANICUM.

EMMA SIRRINE AND EMMA PAMMEL.

Numerous writers have called attention to the value of anatomical studies for diagnostic purposes in the recognition of *Phaenogams*. We may note in this connection the paper by Pfister,¹ who has made a comparative study of the leaves of some palms.

The author considers anatomical characters of value because so many palms are collected without flower or fruit. Bertrand² in a general paper considers the characters and important points to be observed in making anatomical studies of this kind. He notes that we must not lose sight of: 1. Inequalities in the grouping of subdivisions with the association of higher groups. 2. The paucity of material of certain forms, many intermediate species having disappeared in the lapse of time. These objections hold with equal truth to the characters now used in the classification of *Phaenogams*. He states that there are good differential characters in fibro-vascular bundle found in *Gymnosperms*, vascular cryptogams and *Phaenogams*, but the arrangement of the fibro-vascular bundle is of less value. For the families such characters as the veins of leaf; development of stomata; secretion reservoirs; arrangement of inner phloem; for species the cuticle and trichomes are of value in diagnosis.

¹Beitraege zur vergleichenden Anatomie der Sabaleen Blartter. Inaugural Diss. 2 plates, Hofer and Burger (1892) *Abst. Bot. Centralblatt*, LI, p. 300.

²Des caracteres que l'anatomie peut fournir a classification des vegetaux, pp. 54. Antun (Dejussieu) 1891, *Abst. Bot. Centralblatt* Vol. L. p. 375.

Priemer³ states that peculiar hairs, epidermal cells, crystals cystoliths are of value for diagnostic purposes in the order Ulmaceae.

Bordet⁴ has made some anatomical studies of the genus *Carex*. He concludes that in this genus anatomical characters do not offer any material aid in the separation of species. Although some good characters are found in fibro-vascular bundles.

Mez, who has made an exhaustive study of cystoliths and anatomical characters found in the sub-family Cordieae of the order Borraginaceae, finds that hairs are very characteristic and are certainly valuable from a systematic standpoint. Nor should we omit in this connection the valuable paper by Sol-ereder⁵ on the value of the wood structure in dicotyledonous plants, Holle⁶ who has made an exhaustive study of the order Saxifragaceae calls especial attention to the structure of pith cells of *Junoniae*, the characteristic wood cells in certain genera, and crystals in the tribe *Hydrangeae*.

K. Leist⁷ who has likewise made a study of Saxifragaceae concludes that the species of this order offer characters which makes it easy to separate them into groups, but this grouping does not always conform to the present systematic position of its members. Nevertheless general harmony prevails between morphological and anatomical characters as to species.

Several other authors Christ⁷, Thouvenin⁸, Waldner⁹ and Engler¹⁰ have likewise studied this order with reference to different organs and parts.

³Über seine unter Leitung von Prof. Prantl ausgeführten Untersuchungen über die Anatomie Ulmaceen. Bot. Centralblatt, Vol. L, p. 105.

⁴Recherches anatomiques sur le genre *Carex* (Revue generale de Botanique, Vol. III, 1891, p. 57-64. Abst. Bot. Centralblatt, Vol. LI, p. 116.

⁵Über den systematischen Werth den Holzstruktur bei den Dicotyledonen. R. Oldenbourg, Muenchen. 1885.

⁶Beiträge zur Anatomie der Saxifragaceen und deren Systematische Verwerthung. Bot. Centralblatt Vol. LIII. p. 33, 65, 97, 129, 161, 209.

⁷Beiträge der vergleichenden Anatomie der Saxifragaceen. Bot. Centralblatt Vol. XLIII. p. 100, 136, 161, 233, 281, 313, 345, 377.

⁷Beiträge zur vergleichenden Anatomie des Stengels der Caryophyllen und Saxifragaceen. Diss. Marburg, 1887.

⁸Sur l'appareil de soutien dans les tiges des Saxifragées.

⁹Die Kaldruesen der Saxifragaceen. Graz 1887.

¹⁰Monographie der Gattung Saxifraga. Breslau 1873.

Synopsis of North American Pines, based on leaf-anatomy. Bot. Gazette, XI, p. 256, 302; plate VIII.

Die Anatomie der Euphorbiaceen in ihrer Beziehung zum System derselben. Separate Engler's Botanische Jahrbücher, Vol. V, p. 384-421; plates VI and VII.

Mention should be made of the splendid work of Coulter and Rose on the anatomical characters found in the leaves of conifers and their value in the recognition of species. A subject referred to long ago by Dr. George Engelmann. The work of Pax on the anatomy of Euphorbiaceæ, Trecul and others on the stems of many plants.

It will not be necessary to give other references; the literature is quite extensive. More work should be done along this line. We should study the biological relations and the consequent peculiar anatomical structures of plants. It is a field full of interest. Theo. Holm has called attention to the value of this kind of work in studying our flora.

Ganong, in a recent paper with reference to biology and morphology (Present Problems in Anatomy, Morphology and Biology of Cactaceæ, Bot. Gazette, Vol. XX, p. 130), says: "As to the tissues, it is enough here to say that the characteristic *xerophilous* appearances are strong cuticle, thick epidermis, perfect cork, sunken stomata, collenchymatous hypoderma, deep palisade layers; great development of pith and cortex, which consists of large, round, splendidly pitted water-storing cells, often containing mucilage * * * ." The whole system conforms closely to the external form and follows its morphological changes. We notice this especially because the same thing holds true in other plants outside *Cactaceæ*, especially grasses. Great difference occurs between such plants as are habituated to humid climates and those occurring in a dry climate. This offers, indeed, a great field for investigation.

ANATOMICAL STUDY OF GRASSES.

Theo. Holm has done well in calling attention to some anatomical characters of North American Gramineæ. In speaking of the studies which had been made he says: "The importance of studies of that kind was very clear; they not only furnished additional and often even more reliable systematic characters, but the extended study of anatomy into wider fields than ever before, until anatomy has become one of the most important modern lines of botanical science." He emphasizes the importance of internal structure, as it will give a striking illustration of the physiological life of the plant. It will not be necessary here to refer to earlier writers on the subject; suffice

it to say here that Duval, Jouve¹¹, Hackel¹², Güntz¹³, Samsøe, Lünd¹⁴ and Beal¹⁵ have made valuable contributions.

Theo. Holm¹⁶ has studied *Uniola latifolia*, *U. gracilis*, *U. nitida*, *U. paniculata* and *U. Palmeri*, *Distichlis*, *Pleuropogon* and *Leersia*.

From a study of some of the species of *Uniola* growing under widely different conditions, he concludes, that of the five species, the genus show anatomical structures by which they may be easily distinguished.

He says of the genus *Distichlis*, that, "Considered altogether, the anatomical structure of the leaf in the genus *Distichlis* is very uniform, and it does not seem possible to give any special characters by which either of the varieties or the supposed species *thalassica* and *prostrata* may be distinguished from the species *maritima*; because we have seen that male and female specimens of this last show variations among themselves nearly equivalent with the differences in the two varieties and subspecies." Of *Pleuropogon*, he says: "Considering now these three species of *Pleuropogon* together, it is evident that they are, in spite of their great similarity, easily distinguished from each other" by certain anatomical characters taken from leaf blade.

THE GENUS SPOROBOLUS.

The species of the genus *Sporobolus* are nearly all western or southern. Those occurring in Iowa are characteristic western plants and well adapted to dry climate conditions. The following species of *Sporobolus* were studied: *Sporobolus heterolepis* Gray; *S. cryptandrus* Gray; *S. Hookeri*, *S. vaginæflorus*.

SPOROBOLUS HETEROLEPIS.

The epidermal cells (e) are rectangular in shape, with a strongly developed cuticle (c); they vary but little in size. The bulliform cells (b) occur between each mestome bundle (m), except between the last few at the tip of the leaf, where it is occupied by the streome (st.). The bulliform cells occur in four or five rows, a large central cell and three or four smaller cells

¹¹ Histotaxie des feuilles de Graminees.

¹² Monographia Festucarum Europæarum, 1882.

¹³ Untersuchungen ueber die anatomische Structur der Gramineenblaetter, etc. Inaug. Dissert. Leipzig, 1886.

¹⁴ Vejledning til at kjende Graesser i blomterlos Tilstand, Kjobenhavn, 1882.

¹⁵ Grasses of North America for farmers and students.

¹⁶ A study of some anatomical characters of N. America Gramineae. Bot. Gazette, Vol. xvi. p. 166, 217, 275.

on each side. The strongly involute character of the leaf is due to the bulliform cells.

The carene (c') is occupied with one mestome bundle; this bundle is somewhat different than the others, as it is surrounded on the upper side by chlorophyll bearing parenchyma while the lower side contains stereome.

The mestome bundles on right and left of carene are entirely closed (i. e., entirely surrounded by chlorophyll bearing parenchyma). This species is provided with three different types of mestome bundles; the first occurs in carene; this has stereome on lower side in contact with leptome; the second, those which have stereome both on lower and upper side, in contact with leptome and hadrome; and third, those that are entirely closed. Those that are entirely closed occur alternate with those having stereome on upper and lower surface. As to the mestome bundles, there are, in this species, five on left side of the carene and seven on the right side. On the left, the leaf terminates with one closed mestome bundle. The right side of the leaf terminates with three mestome bundles. The mestome bundles, except those at the tip of the leaf, are separated from each other by the bulliform cells and three or four layers of colorless parenchyma. The uncolored parenchyma is more conspicuous near the median nerve, where it is quite strongly developed. In this species the mesophyll does not occur between the bundles but is found only in immediate contact with chlorophyll bearing parenchyma (c b p).

The uncolored parenchyma cells are in immediate contact with stereome. The mestome bundles are entirely closed and do not have leptome (l) and hadrome (h) so well developed as in the other bundles. The leptome in the open bundles (i. e., having stereome in contact with both leptome and hadrome) seem to be in two parts, there being a depression on upper side of leptome.

The stereome occurs on the upper side of all bundles, and also on the lower side of all bundles except those which are entirely closed.

Below the uncolored parenchyma connecting the mestome bundles we find the stereome. The stereome occupies a prominent place on the sides of the leaf, forming on the left two triangular groups of cells separated by two layers of uncolored parenchyma. On the right side three such groups occur between the last four mestome bundles.

The chlorophyll bearing parenchyma can be divided into two parts. First, large parenchyma cells surrounding the bundles; these consist of rather large cells somewhat roundish in shape; second, elongated cells in one or more rows around the first.

SPOROBULUS CRYPTANDRUS.

The epidermal cells in this species do not differ from those described for *S. heterólepis*. The bulliform cells (b) are somewhat larger than those in the first species, usually two or three quite large cells and two smaller on each side. One or two groups of bulliform cells occur between a large mestome bundle, and, as in *S. heterólepis*, these do not occur between the last two bundles.

The carene (c¹) has one mestome bundle (m) which is open on both sides. It is somewhat larger than other mestome bundles. The leptome (l) and hadrome (h) are separated from each other by thick-walled parenchyma (p¹); two rows of thick parenchyma occur around the leptome.

The mestome bundles are of three types: First, those open above and below; second, those open above only, and third, such as are entirely closed. Those of the third type are more numerous than others. One mestome bundle is entirely closed and at the side of the leaf, those of the third type alternate with those of the second and first types. The second type is more numerous than the first. Ten bundles occur on each side of the carene. The mestome bundles of the third type are usually found between two groups of bulliform cells. The chlorophyll bearing parenchyma (c. b. p.) is about as in *S. heterolepis*. The leptome in this species differs from leptome in *S. heterolepis* in not being depressed on the upper side.

The stereome (st) is found on the lower side of all bundles, and also upon the upper side of all bundles except those of the third type. The cells of the sterome are not so thick walled as in *S. heterolepis*.

The mesophyll consists of elongated cells in one or two rows around each mestome bundle. There seems to be mesophyll connecting the bundles beneath the unclosed parenchyma. The unclosed parenchyma is found in one or two rows around the bulliform cells in contact with the mesophyll.

SPOROBOLUS HOOKERI.

The epidermal cells (e) of this species are small, thick walled and uniform in size, they are more roundish than in

other species. The cuticle (c) and cell wall, are well developed in this species. The leaf is strongly involute on the upper surface and here we also find papillae.

The bulliform cells (b) are also much larger than in the other species, there being four to six in a row, sometimes one large central cell and sometimes two large central cells with two smaller bulliform cells on either side of the large ones.

The carene (c), in this species consists of five mestome bundles (m), three very small, a large central, and one medium in size. The leptome (l) and hadrome (h) are fully developed in the two large bundles. The hadrome is separated from the leptome by two layers of thick walled parenchyma. One small mestome bundle occurs on each side of the medium bundle.

The mestome bundles are all connected with each other by the mesophyll (m).

The mestome bundles number thirty-eight, eighteen on left and twenty on right side of carene (c). In this species three types of bundles occur: First, those open on both sides; second, those open above only; and third, those entirely closed. Those of the third type are of two sizes one very small, the other somewhat larger. The mestome bundles of the third type predominate. The sides of the leaf terminate with a closed bundle. In the mestome bundle of the second type the leptome and hadrome seem to be in immediate contact with each other, but in those of the first type they are separated by thick-walled parenchyma. The chlorophyll bearing parenchyma does not differ materially from that found in other species.

The stereome (st) is on the lower side of all the bundles and on the upper side of those of the first and second type. The leaf also terminates with irregular groups of stereome. The stereome is quite well developed in the carene where it occurs in large groups.

The mesophyll (mes) in this species connects the different mestome bundles and consists of both round and elongated cells.

The uncolored parenchyma is more strongly developed in this than in any of the other species of *Sporobolus* studied. It is prominent in the midrib, where it occupies the space above the five mestome bundles. It also occurs immediately below the bulliform cells and on the upper side of the mestome bundles

(m) of the second type connecting these bundles with the stereome.

SPOROBOLUS VAGINAEFLORUS.

In this species the epidermis (e) resembles that of other species except the cuticle (c) which is much more fully developed.

The bulliform cells (b) in this species differ much from those of other species, they are very irregular in outline, the cells ranging in number from eight to ten, and occur almost the entire length of the leaf except near the sides where we find the uncolored parenchyma (p).

The carene (c') consists of one mestome bundle which has stereome in contact with leptome (l). This is the only bundle which is open. On either side of this median bundle there are three or four small closed bundles. The leptome and hadrome (h) are separated by thick walled parenchyma. The mestome bundles number twelve, five to the left and six to the right of the carene. The bundles are of two types: first the median one which is open below and the second, closed; the bundles of this latter type are of two sizes, one very much smaller and the other nearly as large as that of the median nerve. The well developed leptome and hadrome in the median nerve and the larger bundles of the second type are characteristic. The smaller mestome bundles predominate, numbering nine in a leaf. The sterome occurs on upper and lower surface of the mestome bundles of the carene, and large sized mestome bundles of second type, but none are found in contact with smaller sized bundles.

The cells of the chlorophyll bearing parenchyma (c. b. p.) in this species are much smaller than the cells of the other species.

The uncolored parenchyma (p) is found only at the edges of the leaf above the last two mestome bundles.

PANICUM.

The large genus *Panicum* is widely distributed in tropical and warmer countries with a goodly number in temperate climates. The representatives studied by us are common species in the Mississippi valley and southward. The three species, *P. capillare* L., *P. proliferum* L., and *P. crus-galli* L., grow in moist places or where there is considerable rainfall. The weedy *P. capillare* is perhaps an exception, as it is adapted to a wider range of climatic conditions, the structure of the leaf

plainly shows that it can adapt itself to different conditions of soil and moisture.

PANICUM CAPILLARE.

This species has a hairy appearance and is harsh to the touch. The epidermal cells (e) are large, the cuticle (c) and epidermal cell walls are thicker than in *P. crus-galli* and *P. proliferum*, but not so well developed as in the genus *Sporobolus*. The walls of the epidermal cells of the upper and lower surface of the leaf have small conical projections (cp). The end of the leaf terminates in a small thickened point; on the edges of leaf occurs a bundle of stereome (st).

The bulliform cells do not vary much from the epidermal cells, they are somewhat larger, however, and vary in number from three to five, the middle cell being the largest. The carene (c') has one mestome bundle (m) differing from those of secondary veins only in that it is larger, and being open on both upper and lower side. The mestome bundles are of three types: first, those which are open both above and below, second, those which are open below, and third, those which are closed. The leptome (l) is separated from hadrome (h) by thick walled parenchyma (p). In this species the arrangement of mestome bundles is irregular, the number varies from forty to forty-three bundles in one leaf. There are from twenty to twenty-two bundles on each side of the carene, and of these, three on each side are of the first type, three of the second type and the remaining of the third type. In the closed mestome bundles the leptome and hadrome are not so well developed as in those which are open. The stereome occurs on the upper and lower surface of all open mestome bundles, while in those which are closed it is found sometimes on the upper surface and sometimes on the lower surface, and sometimes it is entirely wanting. It consists of from two to four rows, bordering immediately on the chlorophyll bearing parenchyma (c b p). At the sides of the leaf well developed stereome occurs for the purpose of protection.

The mesophyll (mes) consists of elongated cells joining the chlorophyll bearing parenchyma. Between the mestome bundles surrounded by the mesophyll, we have colorless parenchyma.

PANICUM PROLIFERUM.

In this species the epidermal cells are much smaller than in *P. capillare*, and the conical projections (c p) are found more

strongly developed only on the upper surface of the leaf; they are much more numerous than in *P. capillare*, but not nearly so sharply defined. The cuticle (c) is not so strongly developed as in *P. capillare*.

The bulliform cells vary from two to five, usually consisting of one large or two large central cells. The leaf is not so strongly involute in this species, but the bulliform cells (b) extend farther down into the mesophyll (mes) than in *P. capillare*.

The carene (c') has one mestome bundle (m), which is open at the lower side. There are from forty to forty-five mestome bundles in the leaf, the median being the largest. On either side of the carene are five small mestome bundles entirely closed, then occurs a secondary bundle on each side resembling the carene, only much smaller. The leptome is separated from the hadrome in the carene by thick-walled parenchyma cells (p).

The mestome bundles are of two types; first, such as are open below, and second, those that are entirely closed. The closed are much more numerous than the open; only six or seven open in the whole leaf. The leptome (l) and hadrome (h) are not well developed in the small bundles.

The mesophyll consists of elongated and somewhat loosely arranged cells of variable size. One larger surrounds the chorophyll bearing (c b p) parenchyma cells and comes in contact with the stereome (st); the space between the mestome bundles and beneath the bulliform cells is also filled with them.

The stereome is found on the lower side of all bundles, in contact with the parenchyma and epidermis, and also on the upper surface of all the larger mestome bundles.

PANICUM CRUS GALLI.

The most obvious difference between *P. crus-galli* and *P. capillare* is that in this species the leaf is not involute; the epidermal cells (e) are large; the cell wall and cuticle (c) is not so strongly developed but conical projections are found on both surfaces of the leaf.

The carene has one mestome bundle (m). It differs from the other species studied in that the stereome is not in direct contact with the leptome (l) and hadrome (h) but is separated from them by two rows of thick walled parenchyma (p), while the leptome and hadrome are in direct contact with each other.

The mestome bundles are of two types; first, those that resemble the open bundles of other species, only that in this case they are surrounded by thick walled parenchyma outside of which, on two sides occur the chlorophyll bearing parenchyma cells (c b p); second, those that are entirely closed.

The mestome bundles are differently arranged in this species, a small mestome bundle occurs beneath the bulliform cells, this bundle is smaller than the one occurring between the bulliform cells, but is of the same type. Surrounding the bundles of the first type are small chlorophyll bearing cells and more numerous than in the other species studied. The chlorophyll bearing parenchyma cells surrounding those of the second type are larger than those of the first type, but not as large as those of the other type. In this species the leptome and hadrome are in immediate contact while thick walled parenchyma cells surround both.

The stereome is found on the upper and lower surface of all mestome bundles of the first type and separated from leptome and hadrome by thick walled parenchyma. Stereome does not occur around the mestome bundles beneath the bulliform cells. The mestome bundles between the bulliform cells are always closed below and sometimes entirely so.

The mesophyll consists of both elongated and round cells bordering on the chlorophyll bearing parenchyma.

COMPARISON.

A comparison of the two genera shows that in the genus *Sporobolus* the cuticle and cell walls are much more strongly developed than in the genus *Panicum*.

The mestome bundles in *Panicum* are more numerous than in *Sporobolus*. The epidermal cells in *Sporobolus* are uniform in size, in *Panicum* variations occur in different species, while in *P. crus-galli*, the epidermal cells on both sides of the median nerve are smaller than elsewhere on the leaf.

The bulliform cells are larger and more numerous in *Sporobolus* than in *Panicum*.

CONCLUSIONS.

We feel safe in concluding from our study of these genera that the anatomical characters are marked and constant enough to readily enable one to distinguish the species, and along with the work of others it shows that anatomical characters may be used as a basis for the separation of genera and some species.

Fig

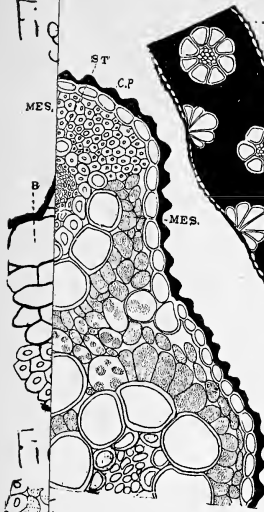
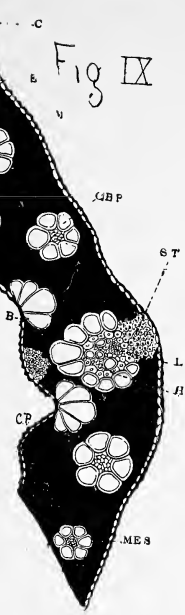


Fig IX

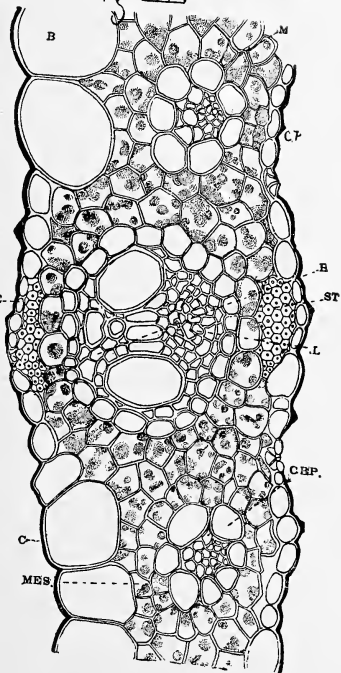


Fig

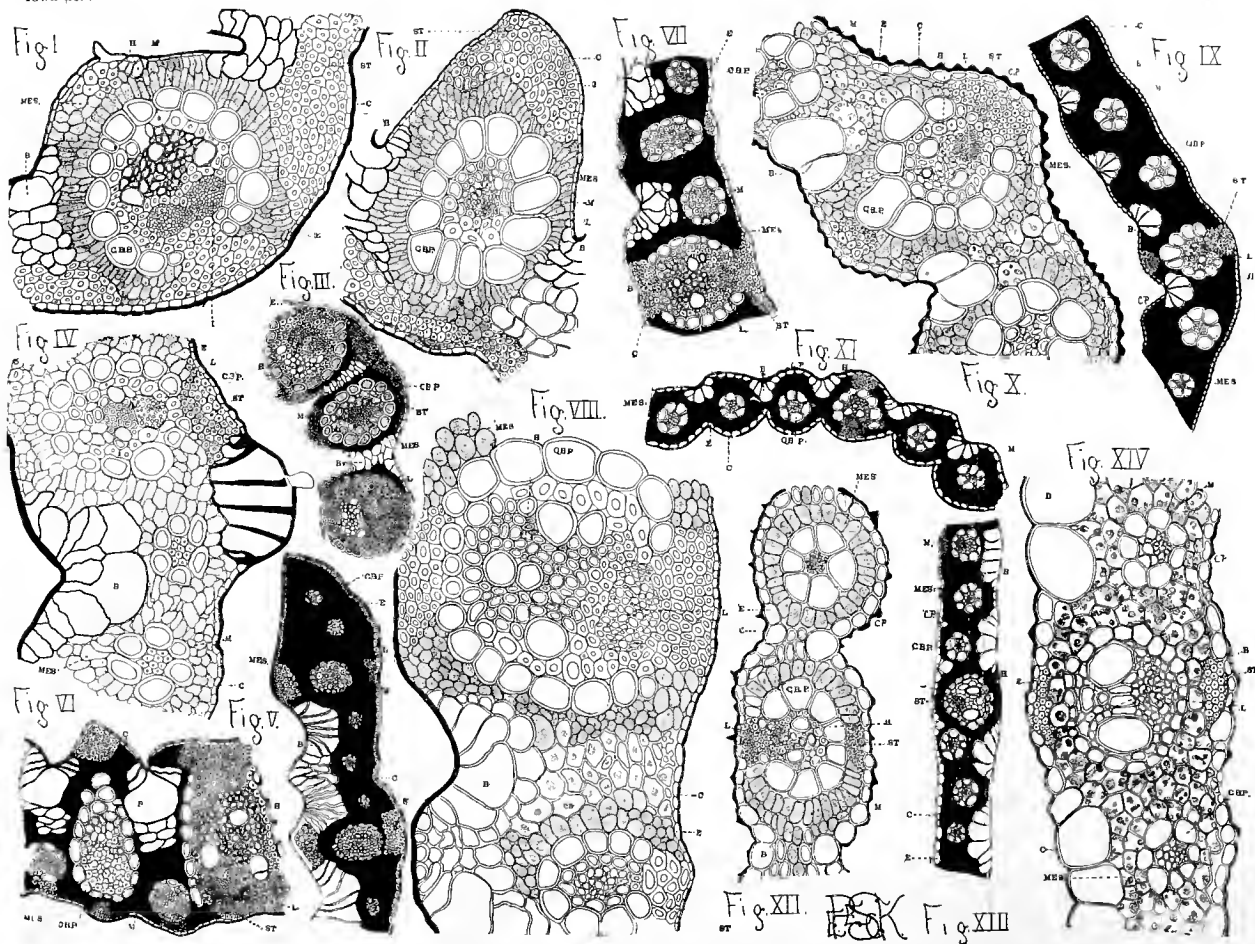
Fig. X.



Fig. XIV



M



EXPLANATION OF PLATE VI.

In all figures the same letter is used for the same character—c, cuticle; e, epidermis; st, stereome; m, mestome; c b p, chlorophyll bearing parenchyma; b, bulliform cells; mes, mesophyll; h, hadrome; l, leptome; c p, conical projections. All figures drawn with camera to the same scale. General drawings $\frac{1}{2}$ inch objective; detailed drawings $\frac{1}{4}$ inch objective.

Figures	I, II, III,	<i>Sporobolus heterolepis.</i>
"	IV, V,	" <i>vaginæflorus.</i>
"	VI,	" <i>Hookeri.</i>
"	VII, VIII,	" <i>cryptandrus.</i>
"	IX, X,	<i>Panicum proliferum.</i>
"	XI, XII,	" <i>capillare.</i>
"	XIII, XIV,	" <i>Crus-galli.</i>

A COMPARATIVE STUDY OF THE SPORES OF NORTH AMERICAN FERNS.

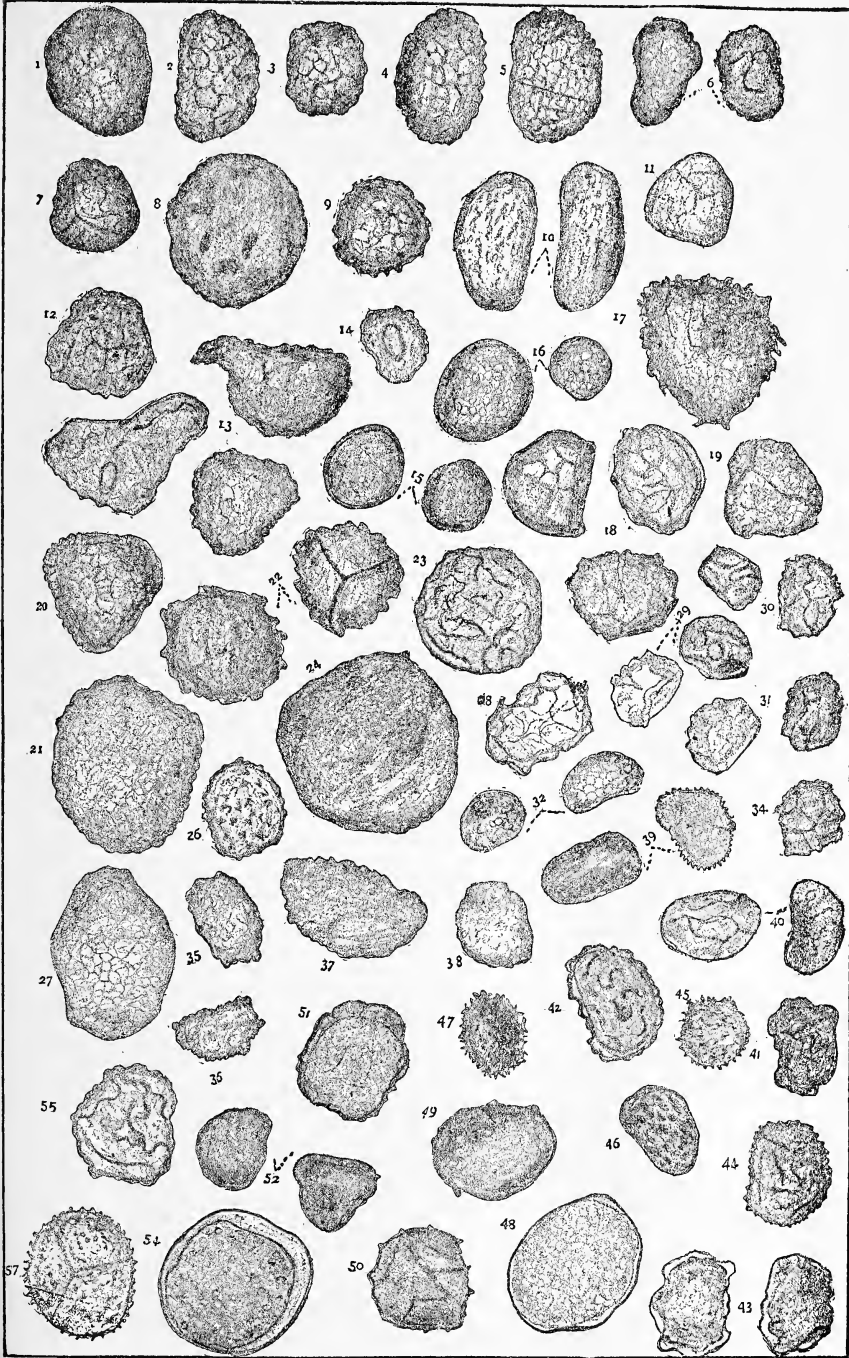
BY C. B. WEAVER.

Ferns have been objects of interest to botanists and cultivators; they have therefore been studied more than many of the flowering plants. Their simple structure and the apparently well defined limitation of species has rendered them easier for purposes of study than many of the groups of Phaenogams.

The purpose of this paper is to make a small contribution toward our knowledge concerning the spore characters of the different genera and species of North American ferns.

The measurements of a few spores are here given:

NAME.	Locality.	Length and breadth of largest spore.	Length and breadth of smallest spore.	Length and breadth of medium sized spore.	DESCRIPTION OF THE SPORES.
<i>Polypodium vulgare</i>	Mo.....	72.6-49.5	56.1-36.6	69.3-46.2	Spores large, smooth.
<i>Polypodium incanum</i>	Mo.....	49.5-33	33.6-29.7	46.2-26.4	Spores smooth on surface.
<i>Notholaena ferruginea</i>	Mass.....	85.8-79.2	66-66	69.3-66	Spores large.
<i>Adiantum capillus-Veneris</i>	Ark.....	52.8-49.5	36.6-36.3	42.9-39.6	Medium size, somewhat irregular, slightly smooth.
<i>Adiantum pedatum</i>	Ark.....	49.5-46.2	42.9-36.3	46.2-42.9	Same as A. capillus-Veneris.
<i>Pteris aquilina</i>	Del.....	36.3-33	29.7-23.1	36.3-33	Spores small, spiny, rough, uniform in size.
<i>Cheilanthes Alabamensis</i>	Tenn.....	54.1-46.2	33-33	49.5-46.2	
<i>Cheilanthes lanuginosa</i>	Iowa.....	62.7-42.9	52.8-42.8	59.4-49.5	Spores medium size, slightly roughened.
<i>Cheilanthes tomentosa</i>	Iowa.....	45-54	33-42	33-45	
<i>Pellaea atropurpurea</i>	Iowa.....	82.5-75.9	66-62.7	66-69.3	Spores large, spiny and slightly roughened.
<i>Woodwardia radicans</i>	Cal.....	69.6-52.8	49.5-39.6	62.7-52.8	Spores oblong, large, not particularly characteristic.
<i>Woodwardia angustifolia</i>	N. Y., L. I.	39-51	33-39	36-42	Similar to W. radicans.
<i>Asplenium trichomanes</i>	Wis.....	33-26.4	26.4-23.1	33-23.1	Spores small; membranous structure not so prominent as in some other species.
<i>Asplenium angustifolium</i>	Mo.....	33-48	24-36	30-42	Spores vary in size, not very rough, reticulated.
<i>Asplenium Filix-foemina</i>	Iowa.....	42.9-29.7	33-23.1	33-25.4	Spores average size, elliptical with rough surface.
<i>Camptoson rhizophyllus</i>	Mo.....	36.3-29.7	33-29.7	46.2-29.7	Spores medium size, somewhat roughened.
<i>Phlegopteris dryopteris</i>	Wis.....	42-27	36-18	33-24	Spores rough.
<i>Phlegopteris hexagonotera</i>	N. Y.....	57-42	27-21	54-39	Spores similar to P. Dryopteris quite rough.
<i>Aspidium Noveboracense</i>	Conn.....	49.5-33	42.9-33	49.5-29.7	Spores not characteristic, rough.
<i>Aspidium Thelypteris</i>.....	.....	56.1-39.6	49.5-36.3	56.1-31	Spores medium size, quite rough.
<i>Aspidium marginale</i>.....	.....	46.2-29.7	29.7-29.7	39.6-29.7	
<i>Aspidium Lonchitis</i>	Utah.....	36.6-29.7	33-23.1	33-33	Spores not large, usually elliptical, some round.
<i>Cystopteris bulbifera</i>	Minn.....	39.6-29.7	33-26.4	33-26.4	Spores medium size, very spiny.
<i>Cystopteris fragilis</i>	Mex.....	48-36	39-33	42-33	Spores not as spiny as C. bulbifera.
<i>Noctea sensibilis</i>	Iowa.....	72.6-59.4	40.5-46.2	54-45	Spores large, very smooth, nearly round.
<i>Noctea struthiopteris</i>	Wis.....	57-39	39-39	49.5-46.2	Spores similar to O. sensibilis, not so large.
<i>Woodsia ilvensis</i>	Wis.....	59.4-46.2	42.9-33	49.5-46.2	
<i>Schizaea pusilla</i>	N. J.....	105.6-69.3	63.3-62.7	89.1-62.8	Spores very large, smooth surface, remarkable for size.
<i>Osmunda regalis</i>	Mo.....	66-66	46.2-46.2	62.7-59.4	Spores rough, resemble S. pusilla in structure, but much smaller.
<i>Osmunda Claytiana</i>	Iowa.....	48-30	36-36	45-27	Spores similar to O. regalis, not so large.



C. B. Weaver, Del.

EXPLANATION OF PLATE.

No.		No.	
1.	<i>Acrostichum aureum.</i>	31.	<i>Asplenium Thelypteroides.</i>
2.	<i>Polypodium vulgare.</i>	32.	<i>Asplenium Filix-foemina.</i>
3.	<i>Polypodium falcatum.</i>	33.	<i>Scolopendrium vulgare.</i>
4.	<i>Polypodium Californicum.</i>	34.	<i>Camptosorus rhizophyllus.</i>
5.	<i>Polypodium pectinatum.</i>	35.	<i>Phegopteris calcarea.</i>
6.	<i>Polypodium aureum.</i>	36.	<i>Phegopteris Dryopteris.</i>
7.	<i>Gymnogramme triangularis.</i>	37.	<i>Phegopteris Polypodioides.</i>
8.	<i>Notholaena ferruginea.</i>	38.	<i>Phegopteris alpestris.</i>
9.	<i>Notholaena nivea.</i>	39.	<i>Aspidium spinulosum.</i>
10.	<i>Vittaria lineata</i>	40.	<i>Aspidium Oreopteris.</i>
11.	<i>Adiantum capillus-Veneris.</i>	41.	<i>Aspidium Novboracense</i>
12.	<i>Pteris longifolia.</i>	42.	<i>Aspidium Thelypteris.</i>
13.	<i>Pteris cretica.</i>	43.	<i>Aspidium acrostichoides.</i>
14.	<i>Pteris longifolia.</i>	44.	<i>Aspidium unitum.</i>
15.	<i>Cheilanthes microphylla.</i>	45.	<i>Aspidium Lonchitis.</i>
16.	<i>Cheilanthes Alabamensis.</i>	46.	<i>Nephrolepis exaltata.</i>
17.	<i>Cheilanthes viscida.</i>	47.	<i>Cystopteris bulbifera.</i>
18.	<i>Cheilanthes lanuginosa.</i>	48.	<i>Onoclea sensibilis.</i>
19.	<i>Cryptogramme acrostichoides.</i>	49.	<i>Woodsia obtusa.</i>
20.	<i>Pellaea gracilis.</i>	50.	<i>Woodsia Ilvensis.</i>
21.	<i>Pellaea atropurpurea.</i>	51.	<i>Woodsia glabella.</i>
22.	<i>Pellaea andromedaefolia.</i>	52.	<i>Dicksonia punctilobula.</i>
23.	<i>Pellaea ternifolia.</i>	53.	<i>Trichomanes Petersii.</i>
24.	<i>Ceratopteris thalictroides.</i>	54.	<i>Lygodium palmatum.</i>
25.	<i>Lomaria spicant.</i>	55.	<i>Aneimia adiantifolia.</i>
26.	<i>Blechnum serrulatum.</i>	56.	<i>Aneimia Mexicana.</i>
27.	<i>Woodwardia radicans.</i>	57.	<i>Osmunda cinnamomea.</i>
28.	<i>Asplenium pinnatifidum.</i>	58.	<i>Osmunda regalis.</i>
29.	<i>Asplenium trichomanes.</i>	59.	<i>Schizaea pusilla.</i>
30.	<i>Asplenium firmum.</i>		

These tables show that there are differences with respect to size and character of species; in some genera species show marked differences in size of spores. *Schizaea pusilla*, the smallest of our ferns, has the largest spores of any species examined, *Onoclea Struthiopteris* has relatively small spores.



Fig. 56. Spores of ferns,
Aneimia Mexicana.

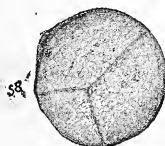


Fig. 58. *Osmunda*
regalis.



Fig. 59. *Schizaea*
pusilla.

INOCULATION EXPERIMENTS WITH GYMNOSPORANGIUM MACROPUS LK.

BY F. C. STEWART AND G. W. CARVER.

The family of true rusts, Uredineæ, is very interesting to the mycologist and important to the agriculturist. It contains about twenty-seven genera and a multitude of species, all of which are strict parasites, living within the tissues of their hosts. Several of the species produce destructive diseases in cultivated plants; as examples note the rust of wheat, oats and other grasses (*Puccinia graminis*, Pers.), blackberry rust (*Caeoma luminatum*, Schw.), and carnation rust (*Uromyces caryophyllinus* [Schrank], Schroeter). Thus far all attempts to cultivate the rusts upon artificial media have failed. Consequently the life histories of some species are imperfectly known. The determination of the life histories of some species is made still more difficult because of the fact that they do not complete their development upon a single species of host-plant, but inhabit different species at different stages in their development. The life history of the common wheat rust, *Puccinia graminis*, so frequently used to illustrate this peculiarity of rusts, is so familiar to readers of botanical literature that it is unnecessary to repeat it here. It is sufficient to state that wheat rust has three stages, two of which are found upon the wheat or some other grass plant and upon the common barberry (*Berberis*).

The species of Gymnosporangium belong to this class of pleomorphic rusts. There are two forms, representing two stages in the development of the fungus. Until about ten years ago these two forms were supposed to be distinct species and were given separate names. The Gymnosporangium form (considered to be the higher form) inhabits, exclusively, species of the Cupressineæ, a group of the family of cone bearing trees, Coniferae. The other form has received the name

Rœstelia. It is found on the apple and allied plants belonging to the tribe Pomeæ, of the family Rosaceæ.

In the United States there are nine species of Gymnosporangium. Chiefly through the investigations of Doctors Farlow and Thaxter, all of them have been connected with their corresponding species of Rœstelia.

Gymnosporangium macropus, Lk., the particular species under consideration, is confined exclusively to the Red cedar, *Juniperus Virginiana*, L. Its Rœstelia form is known as *Rœstelia pirata*, Thax., and is found on cultivated apple (*Pirus malus*, L.), wild crab (*Pirus coronaria*, L.) and Juneberry (*Amelanchier*). The Gymnosporangium may be found in the autumn upon the twigs of Red cedar, where it appears in the form of small brown balls about the size of peas. In May of the following spring these balls enlarge and during rainy weather put out several orange-colored gelatinous horns. At this time the balls are very conspicuous objects and are universally known as "Cedar apples." The gelatinous horns contain numerous two-celled spores on long pedicels. The spores germinate *in situ* each one producing several minute secondary spores which are readily carried by the wind. When these secondary spores chance to fall upon leaves of apples or other suitable plant, they germinate and enter the tissues. In about three weeks, small yellow spots appear on the upper surface of the apple leaf. This is the Rœstelia, and when it is mature the spots will be one-fourth to one-half inch in diameter, yellow above and with tooth like projections beneath. Within the projections are formed round one-celled spores (æcidiospores) which may be carried to a cedar where they will germinate and repeat the life cycle.

The connection of *Gymnosporangium macropus* with *Rœstelia pirata* has been established beyond question by Dr. Thaxter¹. The inoculation experiments here reported were not undertaken for the purpose of obtaining further information concerning the relationship existing between the two forms of the fungus, but rather to ascertain why the cultivated apple in central Iowa should be free from Rœstelia. Although the field has been thoroughly canvassed nearly every season during the past twenty-five years, no species of Rœstelia has ever been taken on any variety of cultivated apple in the

¹On certain cultures of *Gymnosporangium* with notes on their *Rœsteliae*. Am. Acad. Arts and Sciences, 1886, p. 259.

vicinity of Ames, Iowa.^{1a} More than this, repeated efforts to artificially inoculate various varieties of cultivated apples with *Gymnosporangium macropus* have failed. In the spring of 1886 Dr. Halsted² inoculated *G. macropus* on two varieties of cultivated apple (Rawles' Janet and Tallman Sweet), wild crab *Pirus coronaria*³, pear, mountain ash, *Pirus semipinnata*, several species of hawthorn and two forms of Juneberry on the grounds of the Iowa Agricultural College, Ames, Iowa. In no case did *Roestelia* appear on the cultivated apples. He says⁴: "The individual experiments numbered among the hundreds, and in every case there was a perfect failure of the *Gymnosporangium* to grow except with the crab apple, where the inoculation was most emphatic." Further inoculations were made the following season, 1887. He says⁵: "During the present season cultural experiments with the native cedar have been carried out by special students. It is an easy matter to inoculate the wild crab with this, but only failures have attended tests upon other plants." In 1893 Prof. L. H. Pammel⁶ made some inoculation experiments at Ames. A tree of the variety Tetofsky had been top-worked with Fluke crab, which is an improved variety of *Pirus coronaria*; *G. macropus* was inoculated upon both parts of the tree on the same day, with the same cedar apple. In due course of time, *Roestelia* appeared in abundance upon the Fluke crab portion of the tree but not a single leaf of the Tetofsky portion was affected. Inoculations were also made upon pear, Japan quince (*Cydonia Japonica*), cultivated apple and shadbush (*Amelanchier alnifolia*), but these all proved failures.

The above is, in brief, the history of the experiments at Ames previous to 1894. It appears to be well established, that at Ames, Iowa, the cultivated apple is wholly exempt from the *Roestelia* disease which is very abundant and destructive in New England and in some of the southern states. The Red cedar does not grow spontaneously in central Iowa, but it is

^{1a} Professor Pammel writes that he has never known or heard of *Roestelia* on any cultivated variety of apple in Iowa.

²Bulletin of the Iowa Agricultural College, from the Botanical department, November, 1886, pp. 59-64.

³Bailey considers the wild *Pirus* of Iowa to be specifically distinct from *P. coronaria*. He has named it *Pirus lowensis*. See L. H. Bailey's Notes from a Garden Herbarium VI; The Souldard crab and its rise. The American Garden, Vol. XII, p. 469.

⁴L. C., p. 63.

⁵Bull. from the Bot. Dept. of the Iowa Agricultural College, February, 1888, p. 91.

⁶Diseases of foliage and fruit. Report of Iowa State Hort. Soc., Vol. XXVIII, 1893, p. 470.

frequently planted. There are several specimens in [different parts of the Agricultural college grounds, some of them standing in close proximity to apple trees. *Gymnosporangium macropus* is fairly abundant, the amount varying according to the nature of the season as regards moisture. It is usually sufficiently abundant to thoroughly inoculate the wild crab trees. There is only one species of *Gymnosporangium* and only one species of *Ræstelia* at Ames. A second species of *Gymnosporangium*, *G. globosum*, Farl., has been found but once by Professor Pammel⁷. This species occurs in Wisconsin as indicated by Professor Trelease⁸, and may be more common in eastern Iowa. It has not, however, been found since and Professor Pammel writes us that it may have been a chance introduction from material sent to Dr. Halsted. So far as we know, only one species of *Ræstelia* has been found at Ames. This tends to simplify matters considerably. Were it not for the fact that *Pirus coronaria* is so generally affected with *Ræstelia* and so easily inoculated artificially, we would at once conclude that the immunity of the cultivated apple is due to the climatic conditions in Iowa being unfavorable to the growth of *Ræstelia*. It is well known that the range of some fungi is limited by slight differences in climate; for example, the potato-blight fungus, *Phytophthora infestans*, De By., which causes great losses in some parts of the United States, has, I believe, never been collected in the state of Iowa. The climate there is too dry for it.

Another way to account for the facts is to suppose that certain varieties of apples are not susceptible to the disease and that only non-susceptible varieties are grown at Ames. This theory comes nearest to accounting for all the facts. There are two chief objections to it. *First*, the college orchard contains a large number of varieties and it is a remarkable circumstance that they should all be *Ræstelia*-resistant. However, it should be noted that most of them are Russian varieties; *second*, as a case of varietal differences in susceptibility to fungus attacks, it is unparalleled.

In the spring of 1894 we started some inoculation experiments at Ames. *Pirus coronaria* eleven varieties of cultivated apples and the previously mentioned Tetofsky tree top-worked with Fluke crab, were inoculated with the native *G. macropus*

⁷Journal of Mycology, Vol. VII., p. 102.

⁸A Preliminary List of the Parasitic Fungi of Wisconsin, p. 29.

and with *G. macropus* from Cambridge, Mass., by Mr. B. M. Duggar. All were complete failures. The spring and summer were unusually dry. This probably accounts for the failures with Fluke crab and wild crab. Natural cultures of *Raestelia* on wild crab were rare.

In the spring of 1895 one of us being on Long Island, N. Y., and the other at Ames, Iowa, we again undertook some experiments with *G. macropus*. We will speak first of the experiments on Long Island. They were conducted in the nursery of Isaac Hicks & Son at Westbury, N. Y. On May 18th, four varieties were inoculated with New York *G. macropus*—Yellow Transparent, Red Astrachan, Ben Davis and Red Pippin. The first three were two-year-old nursery trees; the last was a large tree. Many leaves on one tree of each variety were smeared, both sides, with the gelatinous spore-masses of *G. macropus*. The results were as follows: Yellow Transparent showed no signs, whatever, of *Raestelia*. Both Red Astrachan and Ben Davis showed yellow spots which appeared like the beginning of *Raestelia*, but none of them developed. Red Pippin produced the *Raestelia*, but the spores did not mature properly and the fungus presented a stunted appearance. On May 24th, six varieties were inoculated with Iowa *G. macropus*—Yellow Transparent, Red Astrachan, Ben Davis, Red Pippin, Maiden's Blush and Wealthy. All were two-year-old nursery trees except the Red Pippin. One tree of each variety was inoculated as before. The results were as follows: Yellow Transparent and Red Pippin showed no signs of *Raestelia*. Red Astrachan and Ben Davis started *Raestelia* spots which never matured. Maiden's Blush and Wealthy developed numerous *Raestelia* spots and matured the aecidiospores thoroughly. As no bags were used to cover the inoculated leaves, it can not be said positively that the *Raestelia* on Maiden's Blush and Wealthy resulted from the Iowa *G. macropus*, but the conditions were such as to warrant the above conclusions. In the case of Red Pippin there can be no doubt as to which inoculation produced the *Raestelia*. A large tree which stood at considerable distance from the other inoculated trees, was inoculated on one side with New York *G. macropus* and on the other side with Iowa *G. macropus*. The leaves of the branch inoculated with New York *G. macropus*, and a few other leaves in the immediate neighborhood, produced *Raestelia* while the remainder of the tree showed not a *Raestelia* spot. It is also

practically certain that all of the *Roestelia* found in connection with these experiments was the *Roestelia* of *G. macropus*. Careful search was made in Mr. Hicks' nursery and in orchards at Floral park and Queens, Long Island, but no *Roestelia* on cultivated apple was found anywhere on Long Island during the season of 1895, except at Flushing, where a few specimens were taken by Mr. F. A. Sirrine.

The following table presents, in a condensed form, the results of the experiments on Long Island:

VARIETY.	MATERIAL USED.*	CONDITION JUNE 15.	CONDITION JUNE 29.	CONDITION AUG. 21.
Yellow Transparent, }	Iowa <i>G. macropus</i> .	No <i>Roestelia</i> .	No <i>Roestelia</i> .	No <i>Roestelia</i> .
Red Astrachan, }	N. Y. ditto.	ditto.	ditto.	ditto.
Ben Davis, }	Iowa <i>G. macropus</i> .	Yellow spots on a few leaves.	No further development.	No further development.
Red Pippin, }	N. Y. ditto.	ditto	ditto.	ditto.
	Iowa <i>G. macropus</i> .	Not observed.	Yellow spots on a few leaves.	No further development.
	N. Y. ditto.	ditto.	ditto.	ditto.
Maiden's Blush, }	Iowa <i>G. macropus</i> .	No <i>Roestelia</i> .	No <i>Roestelia</i> .	No <i>Roestelia</i> .
Wealthy, }	N. Y. ditto.	ditto.	<i>Roestelia</i> appearing.	Partially developed.
	Iowa <i>G. macropus</i> .	<i>Roestelia</i> appearing.	Continuing to develop.	Aecidia well developed.
	N. Y. ditto.	<i>Roestelia</i> appearing.	Continuing to develop.	Aecidia well developed.

* All inoculations with N. Y. *G. macropus* were made May 18.

All inoculations with Iowa *G. macropus* were made May 24.

The experiments at Ames, Iowa, were conducted at the Agricultural college. May 26, 1895, *G. macropus*, from New York, was inoculated on Yellow Transparent, Grimes' Golden, Duchess of Oldenburg, Whitney's No. 20 and *Pirus coronaria*. A large number of leaves on one tree of each were inoculated. In each case, some of the leaves were rubbed on both surfaces with the moistened cedar-apple horns, while others were inoculated by making punctures with a sterilized scalpel. On the same day, other trees of the same varieties were inoculated in the same manner with *G. macropus* collected in Iowa. All of the inoculations, except those on *Pirus coronaria*, failed. But the *Pirus coronaria* trees were so completely covered with *Roestelia* that scarcely a single perfect leaf could be found. What part of this was due to artificial inoculation and what part to natural inoculation it is impossible to say. It simply shows that the season was a favorable one for *Roestelia*.

Our experiments at Ames are entirely in accord with those made by Doctor Halsted and Professor Pammel. Taken in

connection with our experiments on Long Island, they show that some varieties (notably Yellow Transparent) are wholly exempt from *Roestelia pirata* and that there is good reason for believing that the absence of *Roestelia* from cultivated apples in Iowa is not due wholly to unfavorable climatic conditions, but chiefly to the fact that the varieties grown there are not susceptible to the disease. The severe climate of this section has obliged orchardists to abandon all except the most hardy varieties. These are mostly either Russian varieties or varieties which have originated in the northwest. However, the fact cannot be overlooked, that Wealthy, a variety shown by our own experiments to be very susceptible on Long Island, is frequently planted in Iowa, Wisconsin and Minnesota and is there exempt from *Roestelia*. We have by no means a complete solution of this problem.

In the Long Island experiments it is interesting to note that while some varieties showed themselves wholly exempt and others were very susceptible, there were also varieties which presented intermediate degrees of susceptibility. Yellow Transparent showed no signs of *Roestelia*; Maiden's Blush and Wealthy contracted the disease readily and matured æcidiospores; on Ben Davis and Red Astrachan the *Roestelia* started to grow but never reached maturity; on Red Pippin, only part of the æcidiospores matured.

There are few fungous diseases of cultivated plants which are equally destructive to all of the varieties of the species which they attack. Usually some varieties are much more severely attacked than are others. Some varieties may be but slightly affected, while others are ruined. Observant fruit growers know that Flemish Beauty "scabs" worse than most other varieties of pears, while the fungus which produces the leaf-blight and cracking of the pear, *Entomosporium maculatum*, Lev., has a preference for the variety White Doyenne. Wheat growers know that some varieties of wheat are more liable to rust than are others. These are but a few examples. Many more might be mentioned. In the case of *Roestelia pirata*, this preference for certain varieties is carried to the extremes. We know of no other fungus which attacks some varieties of a species so severely and yet cannot even be inoculated upon a large number of other varieties of the same species. Carnation rust, *Uromyces caryophyllinus* (Schrank) Schroeter, perhaps most nearly approaches it. This rust is exceedingly destructive

to some varieties of carnations, while several other varieties are nearly exempt from its attacks. One variety (Wm. Scott) is notably immune. We know of no well authenticated case in which the true rust (*Uromyces*) has been found upon this variety, although we have repeatedly observed it growing in green-houses where other varieties were badly rusted.

In the present state of knowledge concerning the conditions of parasitism, it is impossible to completely explain the immunity of varieties. The structure and chemical composition of a variety are intimately associated with its susceptibility or non-susceptibility to the attacks of a particular fungus; but what is the relative importance of these, or what part is played by the mysterious factor called "inherent vigor" we do not know.

In conclusion we will record our observations on the effect of moisture on the prevalence of *Gymnosporangium* and *Roestelia*. In the spring of 1894 *G. macropus* was fairly abundant at Ames, but the spring and summer were very dry, and, as a consequence of the drouth, *Roestelia pirata* on *Pirus coronaria* was rare. As previously stated, even attempts at inoculation of *P. coronaria* failed that season. In the spring of 1895 showers were frequent during the month of May. This season *Roestelia* was so abundant on *P. coronaria* that it was difficult to find leaves which were *not* affected. Everywhere the wild crab trees were conspicuous because of the *Roestelia* on their leaves.

On Long Island the summer of 1894 was very dry. The Red cedar grows spontaneously here and is very common. May 15, 1895, we searched very carefully through a large grove of Red cedars standing near an orchard and found only *three* cedar apples. At Westbury, N. Y., a Red cedar standing in the midst of a nursery bore only *two* cedar apples. At Queens, N. Y., three Red cedar trees grew on one side of a road, on the other side of which was an orchard; not a single cedar apple could be found on the cedars.

PRELIMINARY NOTES ON THE IOWA ENTOMOSTRACA.

BY L. S. ROSS.

The careful work done by a few investigators has shown the relation existing between our common fresh water fish and the minute crustacea of the streams and lakes. The results of these investigations prove the importance of the Entomotraca as a source of food supply for the young fry of many species, and even for the adults of some. The most extensive work upon this subject is that done by Dr. S. A. Forbes of the University of Illinois. An account of the methods pursued and of the results obtained is given in the bulletins of the Illinois State Laboratory of Natural history; Bulletins Nos. 2, 3 and 6, and articles VII and VIII, Vol. II.

Since the young fish depend for subsistence, to such an extent, upon the relative abundance or scarcity of the Entomotraca, it becomes a question not only of scientific interest, but of economic importance to learn concerning the distribution and abundance of the various species of this group of our fresh water fauna. The knowledge of the vertical distribution of different species in the lakes is of importance because some species of fish feed at one level and some at another. Some have their favorite haunts among the weeds of the shallows, others in the clearer, deeper waters.

Consideration of these facts induced me to begin work upon the occurrence and distribution of Entomotraca in the state of Iowa. The paper presented is a report of work begun, rather than work completed.

In order to combine pleasure with business, I decided to make a bicycle journey to the lake region of Iowa. In the first part of August of the past year, Mr. McCormack of Drake University, and myself started across country en route for Lake Okoboji. We carried vials of alcohol and a coarse and a fine net; the latter being of bolting cloth. The streams did not

offer good collecting ground at that season of the year, as they were nearly all dry. As we did not wish to overburden ourselves, we did not collect dried mud from the ponds and water courses.

Collections were made in a few places from the streams, but principally from West and East Okoboji and Spirit Lake, ranging from the surface to a depth of twenty feet. With the limited apparatus and short time at our disposal, not all the species of the lake were taken, very probably only a minority. To make a thorough investigation the apparatus should be such that hauls could be made among the weeds and along the bottom of the lake, as well as in the clear surface water. Not only should the nets be such as are needed to collect from places of all kinds, but such should be used as are necessary to determine the quantity of life in the water. For collecting in open water or where there is some rubbish, the ordinary fine-meshed net protected by two coarser nets, one outside and the other inside may be used. The inner coarse net should not be as deep as the fine one; it serves to catch and hold back the rubbish. The net or cone-dredge devised by Dr. E. A. Birge of Wisconsin, is the best for collecting among weeds. For quantitative work the plankton apparatus should be used. This is so arranged that the net can be drawn through the water at a definite rate of speed, the speed being regulated so there will be no overflow of water from the mouth of the net. The contents of the net are determined quantitatively as compared with the known amount of water that passed through.

As yet I have determined no species outside the order Cladocera. Of this order probably twenty-five species and varieties have been noted but no new ones have been described, nor have any new to America been found. Undoubtedly, with better apparatus and with more literature upon the subject, many more species may be collected and determined.

The following families are represented in the collections:

Sididae.—By the genera, *Sida* and *Daphnella*.

Daphniidae.—By the genera, *Simocephalus*, *Ceriodaphnia*, *Scapholeberis* and *Daphnia*.

Macrothricidae.—By the genera, *Macrothrix* and *Iliocryptus*.

Lynceidae.—By the genera, *Eurycercus*, *Alona*, *Dunhevedia*, *Pleuroxus*, *Chydorus*, *Camptocercus* and *Leydigia*.

Leptodoridae.—By the genus *Leptodora*

The species found are as follows:

Family <i>Sididae</i>	{ <i>Sida crystallina</i> O. F. M. <i>Daphnella brachyura</i> Liev.
	{ <i>Simocephalus vetulus</i> O. F. M. <i>Simocephalus serrulatus</i> Koch. <i>Ceriodaphnia reticulata</i> Jur. <i>Ceriodaphnia consors</i> Birge. <i>Ceriodaphnia lacustris</i> Birge.
Family <i>Daphniidae</i>	{ <i>Scapholeberis mucronata</i> O. F. M. <i>Scapholeberis obtusa</i> Schdl. <i>Daphnia hyalina</i> Leydig. <i>Daphnia kalbergensis</i> Schoedler. <i>Daphnia kal.</i> var., <i>retrocurva</i> Forbes <i>Daphnia</i> sp?
Family <i>Macrothricidae</i>	{ <i>Macrothrix laticornis</i> Jur. <i>Iliocryptus sordidus</i> Lieven.
	{ <i>Eurycercus lamellatus</i> O. F. M. <i>Alona</i> sp? <i>Dunhevedia setiger</i> Birge. <i>Pleuroxus denticulatus</i> Birge.
Family <i>Lynceidae</i>	{ <i>Pleuroxus procurvatus</i> Birge. <i>Chydorus sphaericus</i> O. F. M. <i>Chydorus globosus</i> Baird. <i>Leydigia quadrangularis</i> Leyd. <i>Camptocercus rectirostris</i> Schdl.
Family <i>Leptodoridae</i>	<i>Leptodora hyalina</i> Lillj.

The distribution of the species is given in the table:

West Okoboji, open lake, from six to eight feet below surface.	{ <i>Daphnella brachyura</i> . <i>Daphnia kalbergensis</i> . <i>Daphnia kal.</i> , variety <i>retrocurva</i> . <i>Daphnia hyalina</i> . <i>Ceriodaphnia lacustris</i> . <i>Chydorus sphaericus</i> . <i>Chydorus globosus</i> . <i>Leptodora hyalina</i> .
West Okoboji, among weeds near shore	{ <i>Sida crystallina</i> . <i>Ceriodaphnia consors</i> . <i>Simocephalus serrulatus</i> . <i>Chydorus</i> sp? <i>Pleuroxus denticulatus</i> . <i>Pleuroxus procurvatus</i> .
Streams near Newell, Iowa	{ <i>Ceriodaphnia reticulata</i> . <i>Simocephalus serrulatus</i> . <i>Simocephalus vetulus</i> . <i>Scapholeberis mucronata</i> . <i>Pleuroxus denticulatus</i> . <i>Chydorus sphaericus</i> .

West Okoboji, fifteen to twenty feet below surface -----	{	<i>Daphnella brachyura.</i>
		<i>Daphnia kal.</i> , variety <i>retrocurva</i> .
		<i>Simocephalus serrulatus.</i>
		<i>Ceriodaphnia consors.</i>
		<i>Eurycercus lamellatus.</i>
		<i>Dunhevedia setiger.</i>
		<i>Chydorus sphaericus.</i>
		<i>Chydorus globosus.</i>
East Okoboji, surface -----	{	<i>Camptocercus rectirostris.</i>
		<i>Sida crystallina.</i>
		<i>Ceriodaphnia reticulata.</i>
		<i>Ceriodaphnia consors.</i>
		<i>Daphnia kal.</i> , variety <i>retrocurva</i> .
		<i>Daphnia hyalina</i>
		<i>Macrothrix laticornis.</i>
		<i>Eurycercus lamellatus.</i>
Spirit Lake, ten to fifteen feet below surface -----	{	<i>Chydorus sphaericus.</i>
		<i>Leydigia quadrangularis.</i>
		<i>Daphnella brachyura.</i>
		<i>Daphnia kal.</i> , variety <i>retrocurva</i> .
Raccoon River, Adel, Iowa -----	{	<i>Chydorus sphaericus.</i>
		<i>Ceriodaphnia reticulata.</i>
		<i>Scapholeberis mucronata.</i>
		<i>Iliocryptus sordidus.</i>
Raccoon River at Sac City -----	{	<i>Pleuroxus denticulata.</i>
		<i>Scapholeberis mucronata.</i>
		<i>Simocephalus serrulatus.</i>
		<i>Chydorus sphaericus.</i>
		<i>Pleuroxus denticulatus.</i>
	{	<i>Alona sp?</i>

THE ANATOMY OF SPHÆRIUM SULCATUM LAM.

BY GILMAN A. DREW.

For a number of years the embryology of the Cyrenidæ has been attracting considerable attention, but little has been added to our knowledge of the general anatomy since Dr. Franz Leydig's publication in 1855 (No. 5), who recorded such anatomy as could be made out from young and rather transparent specimens.*

It is my present intention to continue the work here begun on Sphærium to a comparative anatomy of the Cyrenidæ, but in

*I find a reference to a paper by Temple Prime, entitled: Notes on the Anatomy of the Corbiculidæ and Translation from the Danish of an article on the Anatomy of Cyclas by Jacobson. Bul. Museum Comp. Zool., Cambridge, Vol. V. This volume unfortunately is not to be found in the reference libraries of Baltimore.

the meantime it seems to me that the anatomy of a single genus and a single species of that genus may not be wholly without interest, especially to those who are working in the interior, where the Unionidæ and Cyrenidæ are the only available Lamellibranchs.

Regarding the systematic position of *Sphærium*, suffice it to say that the old genus *Cyclas* includes the present genera *Sphærium* and *Pisidium*, and that these, with four or more other generally accepted genera, go to form the family which has been variously known as *Cycladæ*, *Corbiculidæ* and *Cyrenidæ*.

SHELL.

(Fig. 2.) The shell of this species is comparatively thick, of a dark horn color, frequently lighter near the margins of the valves, and is composed of a rather thick bluish-white nacre, covered exteriorly by epidermis. The lines of growth are well marked. The teeth are thin lamellæ, 2-2 on the right valve and 1-1 on the left valve. The adductor scars, *as* and *ps*, are quite distinct and are joined dorsally by the retractor pedis scars. The pallial line is rather obscure. A large specimen measures 15x12x9 mm.

MANTLE.

The mantle consists of two thin lobes of connective tissue covered by epithelium, free at their anterior and ventral margins, united to form the siphons posteriorly, and continuous over the back. The lobes lie closely applied to the shell nacre, which is secreted by them, and are attached to the nacre at the pallial line by the pallial muscles, and to the epidermis through the epidermal gland, which lies in a groove in the mantle margin. A ridge, Fig. 3, *r*, extending from the ventral end of the anterior adductor muscle to the branchial siphon, runs along the inside of each mantle lobe near its ventral margin and serves, by meeting its fellow on the opposite lobe, or sides of the foot in case that organ is protruded, to close the open side of the branchial chamber and force currents of water to enter through the branchial siphon, which is protruded above the mud or sand in which the animal lives. The siphons, Figs. 1 and 3, *bs* and *cs*, are quite muscular and are capable of considerable protrusion. Neither one is fringed with tentacles.

MUSCULAR SYSTEM.

The muscular system may for convenience be classed as adductors, retractors, foot muscles and mantle muscles, including those of the siphons.

The adductors, Figs. 1 and 3, are two in number, anterior, *aa*, and posterior, *pa*. They differ slightly in size and shape, and have for their only function the closing of the shell.

There are two pairs of retractors, anterior and posterior retractor pedis muscles, Figs. 1 and 3, *arp* and *prp*. They serve to withdraw, or retract, the foot from an extended position.

The foot is largely made up of crossing muscle fibers, extending more or less in all directions, but capable of being classed as longitudinal, vertical and horizontal. They aid in protrusion, by forcing the blood where most efficient, in retraction and in special movements of the protruded foot.

The pallial muscles, Figs. 4 and 5, are distributed to the inner end of the epidermal gland in the edge of the mantle and to the ridge already described. They serve to withdraw the edge of the mantle from between the edges of the valves when the valves are tightly closed.

BYSSAL GLAND.

A rudiment of the byssal gland, Fig. 1, *b*, persists in the adult animal as a single closed sack, often showing a slight sagittal constriction. It is supplied with a small nerve on each side, which spring from trunks that have their origin in the pedal ganglia. Most of the specimens which I have examined have the rudiment of the byssal gland nearer the pedal ganglia than is shown in Fig. 1.

GILLS.

The gills, four in number, consist of a pair, an outer and an inner gill, on each side of the body. The outer, Fig. 3, *og*, is much smaller than the inner, *ig*, and falls short anteriorly by about a fourth of its length. Each gill is composed of two lamellæ. The outer lamella of the inner gill is attached to the inner lamella of the outer gill on the same side, the outer lamellæ of the outer gills are attached to the mantle lobes on their respective sides, and the inner lamellæ of the inner gills are attached anteriorly to the body wall and posteriorly to each other, Fig. 5. The gills function as respiratory organs, procurers of food and brood pouches. The latter function is monopolized by the inner gills, which carry the embryos until they are ready to function as adults.

Fig. 6, which represents a piece of gill cut squarely across the lamellæ and seen obliquely from the cut surface so that the

side of a lamella may be seen, may aid in understanding the structure of a gill. The descending and ascending portions of each filament, *f i l*, are fused throughout their length, thus uniting the lamellæ at very short intervals and restricting individual water-tubes, *w t*, between adjacent filaments.

The filaments are strengthened by chitinous rods, *c r*, and attached to one another laterally by inter-filamenter junctions, *i f j*, which are places where, during development, adjacent filaments have fused together. There are thus left openings, *i o*, known as inhalent ostea, which lead into the water-tubes. Beneath the epithelial covering of the filaments is a loose connective tissue, through which more or less definite blood spaces, *b l s*, may be traced. The outer surfaces of the filaments are covered with rather short cilia, besides which there is a row of longer cilia on each side of each filament near the outer surfaces, and another row of long cilia placed far in on the sides of the filaments, nearly opposite the chitinous rods. It seems that the inner rows of cilia serve largely to drive the water through the inhalent ostea and water-tubes and thus keep up a continuous supply of fresh water, while the other cilia are engaged in forming surface currents and in separating and transporting food particles.

LABIAL PALPI.

The labial palpi, Fig. 3, *l p*, are very long and slightly curved. There is a pair, consisting of an outer and an inner palp, on each side of the body. The anterior edges of the outer palps are connected in front of the mouth by a slight ridge, as are likewise the anterior edges of the inner palps behind the mouth. The adjacent sides of each pair are grooved and densely ciliated. Particles of food passed between them from the gills are transported to the mouth.

ALIMENTARY CANAL.

The mouth, situated behind the anterior adductor muscle leads into a rather long and slender œsophagus, Fig. 1, *o e*, which communicates with a somewhat spacious horn-shaped stomach, sacculated at its upper end, which curves downward and forward and gradually tapers into the intestine which at this point forms a coil. The relative positions of the loops of this coil to one another, may be made out by comparing Fig. 1, with Fig. 4, which latter represents an obliquely transverse section through the coil. The stomach 1, situated on the left

side of the body, communicates anteriorly with 2, which, near the plane of the section turns to form 3, and so on. It is of interest to note that in the young animals no such coil exists. As the alimentary canal lengthens the loops are formed and gradually lengthen. Fig. 1 is reconstructed from a smaller and apparently younger individual than the one represented in section by Fig. 4, and it will be observed that the loop 4 5, Fig. 4, must be longer than the corresponding loop of Fig. 1, else the arms could not be separate at a point where the loop 2 3, is turning. From the point 6, the intestine follows back along the convex border of the stomach, then rather abruptly turns nearly at right angles to its former course, passes through the ventricle of the heart, then passes over the posterior adductor muscle dorsally and posteriorly to open in the cloacal chamber. The typhlosole is not strongly developed but is present as a small ridge as shown in Fig. 5.

The alimentary canal throughout its length is lined by elongated ciliated epithelial cells. Fig. 9 represents these cells as they appear in a section through the lower end of the stomach.

LIVER.

The liver, Fig. 1, *l*, is a paired organ, consisting of two large racemose glands, one on each side of the body. Each gland communicates with the stomach through anterior lateral pouches. The liver cells are often densely crowded with granules that stain deeply, but not infrequently part of the cells of some follicles will be full while adjacent cells will be empty. This condition is indicated by Fig. 10.

It is not unlikely that, as the animal probably feeds most of the time, digestion is a continuous process and that the liver cells are continually filling up and discharging.

NERVOUS SYSTEM.

The regular three pairs of Lamell branch ganglia are present. The cerebral ganglia, Fig. 1, *c. g.* lie on opposite sides of the oesophagus, on a level with the dorsal end of the anterior adductor muscle. They are somewhat oblong in shape and are connected with each other by an oesophageal commissure which runs between the oesophagus and the anterior adductor muscle. The parieto-splanchnic ganglia Fig. 1, *p s g*, also oblong in shape, lie anterior to the ventral portion of the posterior adductor muscle and are fused together by their adjacent sides. The pedal ganglia, Fig. 1, *p g*, are more nearly circular than

either of the other ganglia, when viewed from the side. They lie beneath and a little posterior to the intestinal coil at the line where the muscles of the foot come in contact with the connective tissues of the body proper, Fig. 4. The pedal ganglia are likewise fused together by their adjacent sides.

The cerebral ganglia are connected, Fig. 1, with the parieto-splanchnic ganglia by the cerebro-visceral commissures and with the pedal ganglia by the cerebro-pedal commissures. Beside these commissural connections each cerebral ganglion gives rise to a small nerve which supplies the anterior adductor muscle and a larger nerve which passes down behind the anterior adductor muscle into the mantle and supplies the pallial muscles of its anterior portion.

Each parieto-splanchnic ganglion besides its commissural connection, gives rise to a small nerve which supplies the posterior adductor muscle, a larger branchial nerve which runs forward a short distance, passes over into the junction of the outer lamella of the inner gill with the inner lamella of the outer gill, where it turns abruptly backward and apparently ends at the posterior ends of the gills not greatly reduced in size, and a large nerve that runs around the ventral surface of the posterior adductor muscle and branches. The smaller branch is probably distributed to the muscles of the siphons, but I have been unable to follow it far. The larger branch runs along the mantle near the inner ends of the pallial muscles, giving off a branch near the upper border of the branchial siphon and numerous small branches to the pallial muscles.

Each pedal ganglion, besides its commissural connection, gives rise to at least five more or less distinct nerves which branch among the muscles of the foot.

OTOCYSTS.

A pair of otocysts, Fig. 1, *o t*, lie directly in front of the pedal ganglia, almost, if not quite in contact with the cerebro-pedal commissures. They are nearly spherical in shape, and consist of a wall of cells with a nearly spherical otolith inside (Nos. 4 and 5). Thus far I have been unable to find cilia in the otocysts, but this may be the fault of preservation. The otocysts of most Lamellibranches are described as being enervated by fibres from the cerebro-pedal commissures. With *Sphærium* a small branch is given off from the nerve which passes immediately below each otocyst that passes up, and may

often be traced into contact with the otocyst, but I have been unable to demonstrate actual connection with this or with fibres from the cerebro-pedal commissure. Regarding the function of otocysts see Dr. Brooks' article (No. 1).

CIRCULATORY SYSTEM.

The heart, Figs. 1 and 5, consisting of a single median ventricle, *v t*, and a pair of lateral auricles, *a u*, lies in the pericardial cavity, near the dorsal surface of the animal, and somewhat in front of the posterior adductor muscle. All the blood channels issuing from the ventricle are without very definite walls or calibre. Immediately in front of the pericardium the blood channel, Fig. 1, which leaves the heart in this direction, divides. The larger branch is continued forward along the dorsal line of the body, turns to the left and passes beneath the oesophagus, which it follows to the mouth. When opposite the dorsal end of the anterior adductor muscle, a branch is given off which passes in front of the adductor and, dividing, sends a branch to each mantle lobe. The main channel is continued down in front the cerebro-pedal commissures into the foot, where it divides into a number of small branches that apparently ultimately end in the connective tissue spaces with which the whole body is permeated. The smaller branch, which arises immediately in front of the pericardial cavity, passes downward, sends a branch to either side of the stomach, supplying that organ throughout its length with small branches, and finally ends among the loops of the intestinal coil.

Posteriorly the ventricle gives rise to a channel of considerable dimensions which surrounds the intestine, but is more spacious beneath than above it. The intestine seems to be held in the dorsal part of this channel by strands of connective tissue. Behind the posterior adductor muscle this channel widens on opposite sides of the intestine and is continued into the mantle lobes. It is not improbable that other important channels exist. Fig. 5 is a section across the body in the region of the heart showing the connection that exists between the auricles and the blood spaces of the gills.

ORGANS OF BOJANUS.

The organs of Bojanus consist of a pair of coiled and sacculated tubes, one on each side of the body, lying between the pericardium and the posterior adductor muscle. At one end

each organ opens into the pericardial cavity, and at the other end into the cloacal chamber. Fig. 1, *o B*, shows the right organ as seen from the left or inner side, and Fig. 7 is a diagram of the left organ as seen from the left or outer side. By comparing the two figures the relations of the loops will be seen. The cells lining the organ are apparently not glandular in the immediate vicinity of the pericardial opening, and are rather small near the cloacal opening, but throughout the rest of the tube the cells are large and vacuolated, as shown by Fig. 11, which represents specially large cells from the dorsal part of the organ. I have been unable to find cilia on any of the cells.

REPRODUCTIVE ORGANS.

The animal is hermaphroditic. The reproductive organs, which are paired, each consist of a racemose gland, Fig. 1, *r o*, situated beneath the pericardium and behind the stomach, varying in extent according to the age of the individual, and opening into the cloacal chamber close to the cloacal opening of the organ of Bojanus. Part of the follicles bear ova, others sperm. The ova-bearing follicles are generally among those most posterior. They are fewer in number than the sperm follicles, and, in this species, bear comparatively few ova. Fig. 8 represents a section of an ova-bearing follicle, in which are a number of nearly or quite mature and several very young ova. The sperm-bearing follicles are generally full of sperm, which lie free in their cavities. Reproduction, apparently, goes on during the greater part of the year.

LITERATURE.

1. Brooks, W. K. Sensory Clubs or Cordyi of Leodice. Jour. of Morph. Vol. X, No. 1.
2. Kellogg, James L. Contributions to our Knowledge of Lamellibranchiate Mollusks. Bul. U. S. Fish Commission, 1890.
3. Lang, Arnold. Lehrbuch der Vergleichenden Anatomie.
4. Lankester, E. Ray. Mollusca. Enc. Britt.
5. Leydig, Franz. Ueber Cyclas Cornea. Müller's Archiv., 1855.
6. Mitsukuri, K. On the Structure and Significance of some Aberrant Forms of Lamellibranchiate gills. Quart. Jour. Mic. Sci., Vol. XXI, 1881.
7. Peck, R. H. Gills of Lamellibranchiate Mollusca. Quart. Jour. Mic. Sci., Vol. XVII, 1877.
8. Pelsener, Paul. Contribution à l'étude des Lamellibranches. Arch. de Biol., Tome XI, Part 2, 1891.
9. Rankin, Walter M., Über das Bojanus'sche Organ des Teichmuschel. Jena, Zeit. Bd. XXIV, 1890.
10. Zeigler, E. Die Entwicklung von Cyclas cornea Zeit. f. wiss. Zool., Bd. XLI.

My thanks are due to Mr. C. P. Sigerfoos for the loan of series of sections of two undetermined species of *Sphærium*, with which some comparisons were made.

EXPLANATION OF PLATES.

- a a.* Anterior adductor muscle.
- a o.* Anterior aorta.
- a r p.* Anterior retractor pedis muscle.
- a s* Anterior adductor muscle scar.
- a u.* Auricle.
- b.* Byssal gland rudiment.
- b l s.* Blood space.
- b s.* Branchial siphon.
- c.* Cloacal chamber.
- c g.* Cerebral ganglion.
- c r.* Chitinous rods.
- c s.* Cloacal siphon.
- f.* Foot.
- f i l.* Gill filament.
- i f j.* Inter-filamentar junctions.
- i g.* Inner gill.
- i o.* Inhalent ostea.
- l.* Liver.
- l p.* Labial palpus.
- m.* Mantle.
- o B.* Organ of Bojanus.
- œ.* Œsophagus.
- o g.* Outer gill.
- o t.* Otocyst.
- o v.* Ovarian follicle.
- p.* Pericardial cavity.
- p a.* Posterior adductor muscle.
- p g.* Pedal ganglion.
- p r p.* Posterior retractor pedis muscle.
- p s.* Posterior adductor muscle scar.
- p s g.* Parieto-splanchnic ganglion.
- r.* Mantle ridge.
- r o.* Reproductive organs.
- t.* Male follicle.
- v t.* Ventricle.
- w t.* Water-tube.

PLATE I.

Fig. 1. A reconstruction of an adult specimen from serial sections, seen from the left side. Median, and the paired organs of one side shown. The liver and reproductive organs of older specimens are more extensive.

PLATE II.

- Fig. 2. Enlarged view of the outside of the right valve and the inside of the left valve of a shell.
- Fig. 3. View of the animal with the right valve of the shell removed, and most of the right mantle lobe cut away.
- Fig. 4. Oblique cross-section of an animal through the intestinal coil and the pedal ganglia. Seen from behind.
- Fig. 5. Section through the heart in the same series as preceding.

PLATE III.

- Fig. 6. Cross-section of a piece of gill seen obliquely from the side so as to show both the section and the outer surface of a lamella.
- Fig. 7. Diagram of the outer, left, side of the left organ of Bojanus.
- Fig. 8. Section across an ovarian follicle.
- Fig. 9. Epithelial lining of the distal portion of the stomach.
- Fig. 10. Liver follicle showing charged and discharged cells.
- Fig. 11. Epithelial cells of the organ of Bojanus.

A STUDY OF THE GENUS CLASTOPTERA.

ELMER D. BALL.

In the development of the hind tibiae and the structure and venation of the wings, the insects under consideration represent the highest and most specialized forms of the Cercopidæ if not of the Homoptera; marking, as Uhler suggests, an important advance toward the Heteroptera in the increased freedom of the anterior coxae and the possession of a terminal membrane to the corium.

In order to correctly establish generic characters it will be necessary, first, to separate off those of family value.

FAMILY CERCOPIDÆ.

The representatives of the family in this country, at least, agree in possessing the following characters:

Front inflated, convex or compresso produced; antennae inserted in front of and between the eyes; ocelli, two, situated on the disc of the vertex; thorax large, sexangular or trapezoidal; hemelytra coriaceous; posterior coxae and femurs short, tibiae spatulate, armed with two spurs, the first once, the second twice as long as tibiae are wide; tibiae and two first joints of tarsi terminated with crescent-shaped rows of spines, third joint with a bifid claw.

The following genera are represented in the United States: *Monephora*, *Lepyronia*, *Aphrophora*, *Philaenus* and *Clastoptera*. These may be easily separated by the character of the venation of either pair of wings by reference to plate XII.

The *Clastoptera* may be separated from the others, directly, by the rounded apex of the clavus and the terminal membrane of the corium.

CLASTOPTERA.

Germar's original description published in his "Zeitschrift fur Entomologie," Vol. I, p. 157, is as follows:

Kopf gross, stumpf dreieckig, so breit wie der Vorderrucken, Stirn gewolbt, querstreifig, Scheitel breit viereckig, vorn und hinten scharf gerandet, die Nebenaugen auf der mitte des Scheitels genahert. Schnabel bis an die Hinterbrust reichend. Fuhler in einer Grube an der Wurzel der Wangen, sehr kurz, mit langer feiner Endborste. Vorderrucken breit am Scheitel vorgezogen und gerundet, bei den Augen gebuchtet, von den Schultern nach hinten in einer Rundung verschmalert, an der spitze schmal aber tief ausgerandet. Schildchen ein langgezogenes spitzwinkeliges dreick bildend. Deckschilde lederartig, an der Spitze gewolbt, uber einander klapfend, die hintere Randader weit von dem Hinterrande entfernt. Flugel hautig, unter den Deckschilden vorborgen. Beine maszig lang, unbewehrt um die hintersten verlangert, mit zwei stacheln am Rucken die Schienen und einem Dornenkranze an der Spitze der Schienen, und ersten beiden Tarsengliedern.

A careful study of all the American forms leads to the following summary of characters:

Broad, oval forms; very variable in size and color markings; front inflated, circular, not longitudinally carinated; antennæ arising from a deep cavity between the eyes, basal enlargement not extending outside of cavity; vertex narrow, transversely depressed, outline regular, not inclosing front; eyes broad, a row of curved hairs on the outer and posterior margin; pronotum convex, trapezoidal, transversely wrinkled, deeply emarginated behind; scutellum narrow, triangular, longer than pronotum; hemelytra convex, deflected posteriorly, overlapping behind in a perpendicular plane; corium with three apical cells and two widely separated discoid cells, a broad membrane beyond; membrane and apical cellules hyaline; clavus with apex broadly rounded; an oval, convex, callous dot near apex of hemelytra; under wing with a single discoid cell, terminal apical cell open; posterior tibia with a single terminal row of spines; ovipositor carried perpendicular to the plane of the body; males usually smaller and slightly darker than females; smallest varieties nearly black.

Specific characters are based upon the size and shape of front, the facial angle, sculpturing of vertex and pronotum, size and shape of discoid and apical cells, pubescence of pronotum and hemelytra, and the color markings of the face and legs.

Sub-species are based upon size, food habits and associated groups of constant color markings; varieties, on locality, size and color markings of vertex, pronotum and clavus.

SYNOPSIS OF SPECIES.

- A. Front strongly inflated, rising abruptly from face at sides, meeting vertex in same plane; pronotum with broad wrinkles; first discoid cell equal to second.
- B. Front, outline a regular curve, entirely black, or yellow with transverse interrupted brown bands above, light below; pronotum scabrous, with about eight distinct wrinkles; veins on clavus prominent.....*delicata*, Uhl.
- BB. Front, outline an irregular curve, upper half black with a narrow yellow margin next to vertex, lower half yellow, loræ and clypeus yellow; pronotum, bare, with about twelve indistinct broad wrinkles.....*proteus*, Fitch.
- AA. Front, less inflated, rising gradually from face at sides, meeting vertex at an obtuse angle above; pronotum finely, sharply wrinkled, about twenty on the median line; first discoid cell smaller than second.
- B. Hemelytra strongly impunctured, sparsely pubescent; second apical cell short and broad; insects small, of a uniform color above.....*xanthocephala*, Germ.
- BB. Hemelytra minutely impunctured, thickly finely pubescent, second apical cell long and narrow; insects large, usually banded above.....*obtusa*, Say.

ARTIFICIAL KEY TO SPECIES.

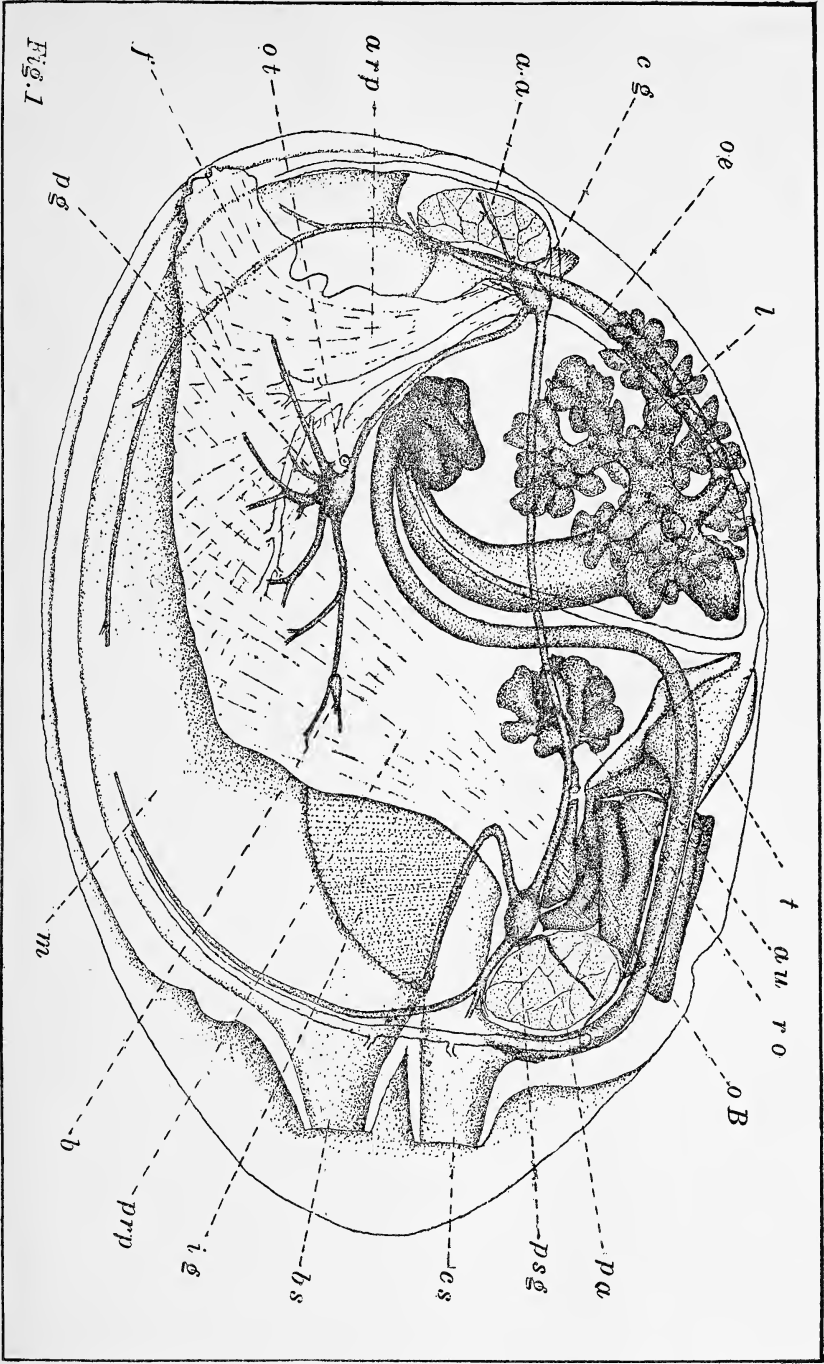
- A. Face entirely black.....*delicata-lineata*, var. *b.* or *binotata*.
- AA. Face not entirely black.
- B. Upper half of front black; loræ, clypeus and lower half of front yellow.....*proteus*.
- BB. Upper half of front light with transverse, interrupted, brown bands.
- C. Pronotum with five transverse straight black bands, not parallel with anterior margin.....*delicata-lineata*, var. *a.*
- CC. Bands on pronotum parallel to anterior margin or wanting.
- D. Hemelytra strongly impunctured, sparsely pubescent; pronotum without bands; lower half of face with a light band; insects small.....*xanthocephala*.
- DD. Hemelytra minutely impunctured thickly, finely pubescent; pronotum generally banded or colored where not, face all light; insects large.....*obtusa*.

C. DELICATA UHL.

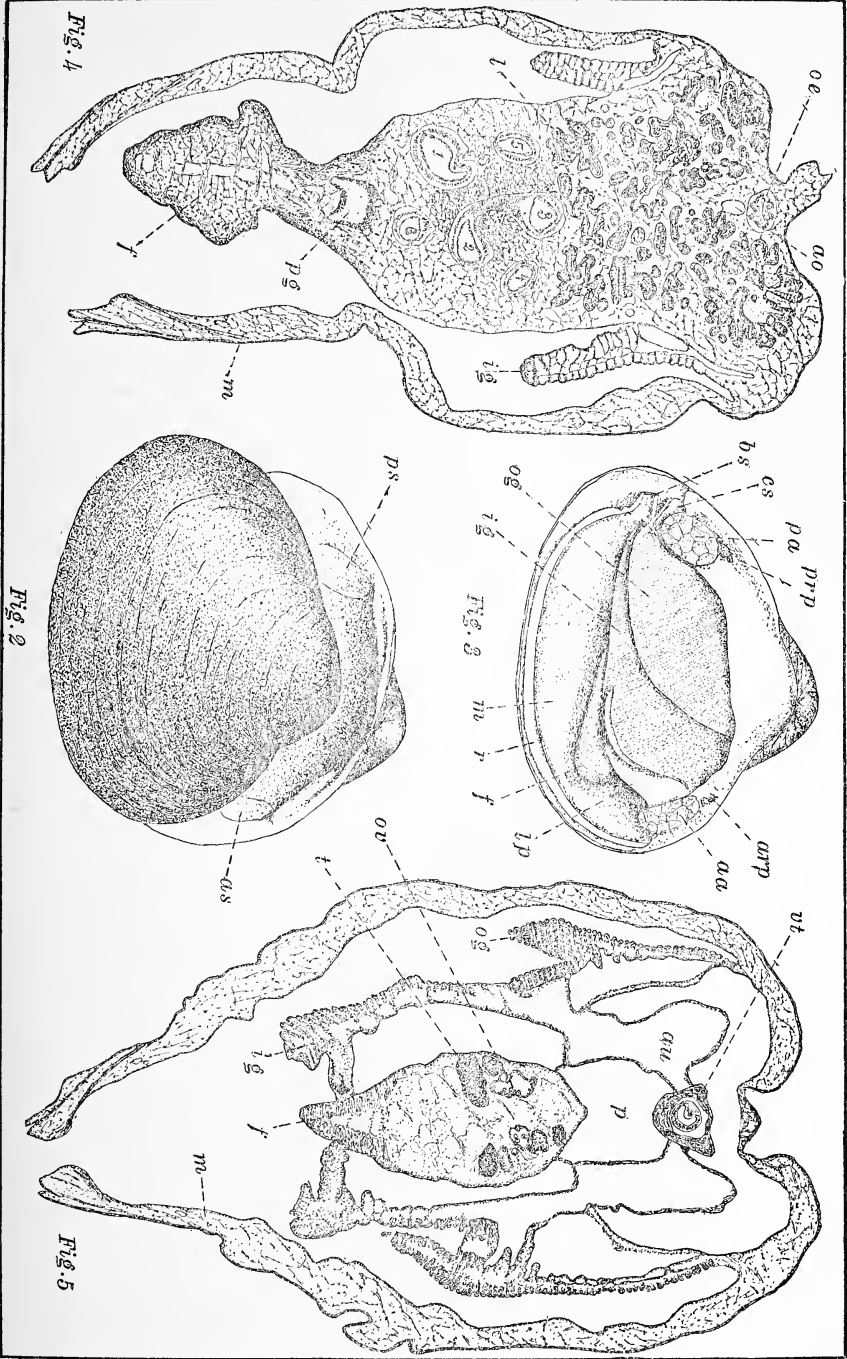
C. binotata Uhl. ms.

Uhler's original description found in his list of Hemiptera west of the Mississippi river is as follows:

Form of *C. proteus*, Fitch, but with a more prominent front. Pale greenish-yellow. Head broad, apparently impunctate; cranium short, transversely depressed, as is also the tylus; anterior edge of the vertex carinately elevated, bordered from eye to eye with a black line; eye margined behind with black; front smooth, polished, bright yellow, rounded, the transverse rugæ substituted by slender black bands; lower down grooved, and with a broad black spot, adjoining which each side on the cheeks is a smaller spot;



Gilman A. Drew, del.



under side bright yellow; rostrum black, reaching almost to the posterior coxæ; antennæ black at base. Pronotum banded on the anterior margin by a slender black line, and with five straighter and more slender lines which stop just short of the lateral margins, these lines feebly impressed and obsoletely, minutely scabrous, surface not wrinkled, almost smooth, moderately convex, deeply emarginated behind, the lateral margin narrowly produced as far as the outer line of the eyes; the humeral margin recurved, and with a small black dot before it. Scutellum pubescent, yellow, transversely wrinkled, with a slender black line at base, and an interrupted one behind the middle. Hemelytra with short, remote, golden pubescence, coarsely punctate at base, more obsoletely so posteriorly; the inner and posterior margins, the suture between the corium and clavus, an oblique short streak on the disc, and a spot on the middle of the costa fuscous; posterior margin of the corium with a sinuous brown band, the membrane and posterior one-third of the corium, and spot at base of costa pale brown; the bulla very prominent, black; under side yellow; the mesostethium, discs of the plural pieces, and middle line of genital segment pitch black. Legs, yellow, the tibiæ having a band below the knee, another on the middle, and a third at tip, and the spines of tibiæ and tarsi, including the nails, dark piceous.

Length to the tip of hemelytra, four and one-half mm., width of pronotum, two mm.

After a careful study of representatives from every state from which it has been reported so far, the following description, embracing only characters of specific value was prepared.

Size variable; color from yellow to black; front much inflated; two circular yellow depressions on vertex near eyes; pronotum strongly, broadly wrinkled.

Front rising abruptly from face at sides, meeting vertex in same plane above, outline a regular curve. Vertex very slightly transversely depressed; a distinct, circular, yellow depression midway between eye and ocellus on either side. Pronotum coarsely pubescent, strongly, transversely, wrinkled, about eight on the median line. Hemelytra coarsely pubescent; veins on clavus strongly raised; apical cells transversely compressed, third cell triangular, not reaching beyond angle of posterior marginal vein. Legs stout; spurs and spines strong; femur and tibia with dark lateral lines coalescing with two dark spots on outside of tibia.

Sub. sp. I. *lineata*. Pronotum yellow, with five black bands.

Var. *a*. Clavus with veins and margin yellow inclosing dark areas.

b. Clavus entirely fuscous.

Sub. sp. II. *binotata*. Pronotum entirely black.

Habitat: Utah (Uhl), Cal. Col. and Ariz.

This species is so widely variable that with only the extreme forms there would be no hesitancy in pronouncing them separate species, but with a large amount of material a series can be found which clearly establishes their relationship. Uhler's description is an absolutely perfect one for Sub. sp. *lineata* var.

a, but would apply only slightly to var. *b*, and would absolutely exclude Sub. sp. *binotata*.

C. binotata was a ms. name given to that var. by Uhler, I believe, and under which name specimens have been distributed in collections.

C. PROTEUS, FITCH.

C. saint cyri. Prov.

The original description was published in the fourth annual report of the New York State Museum (1851). Republished in the ninth report of the State Entomologist of New York, page 394, from which the following description and sub-divisions are copied:

Head bright yellow, a black band on anterior margin of vertex and a broader one on the front; front polished, without transverse striæ; a callous black dot near the apex of the elytra; legs yellowish-white, tarsi black. Length, 0.16; males slightly smaller.

Closely allied to the *C. atra* of Germ, but on examining a host of specimens not one occurs in which the legs are annulated with black or fuscous.

He then divides the species up into sub-species and varieties as follows:

Sub. sp. I. *flavicollis*. Thorax entirely yellow.

Var. *a*. Elytra yellow.

b. Elytra with an oblique blackish vitta.

Sub. sp. II. *cincticollis*. Thorax with a black band.

Var. *a*. An interrupted black band on the anterior margin of the thorax.

b An entire black band on anterior margin of the thorax.

c. Thoracic band crossing the disk instead of the anterior margin.

d. Band on the disk of the thorax, and scutell black.

Sub. sp. III. *maculicollis*. Thorax with one or two discoidal spots.

Var. *a*. A black spot on disk and an interrupted band anteriorly.

b. A black spot on the disk and anterior band entire.

c Two black spots on the disk of the thorax.

Sub. sp. IV. *nigricollis*. Thorax black, with a yellow band forward of the disk.

Var. *a*. The black band on the anterior margin of the thorax interrupted.

b. The band continuous.

c. Scutell black, with a yellow dot at its base.

d. Scutell entirely black.

Fitch's "host" of specimens were probably all from one locality and may all have belonged to one sub. sp., according to my classification below. At any rate I have at hand four specimens, that are all clearly and unquestionably varieties of

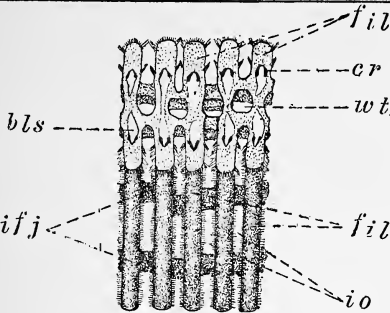


Fig. 6

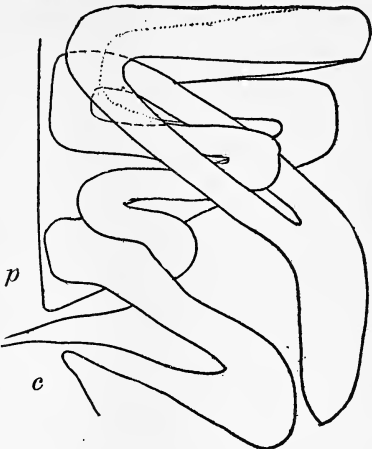


Fig. 7

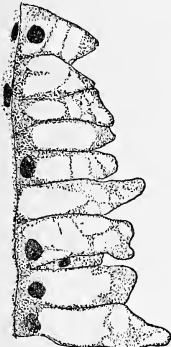


Fig. 11

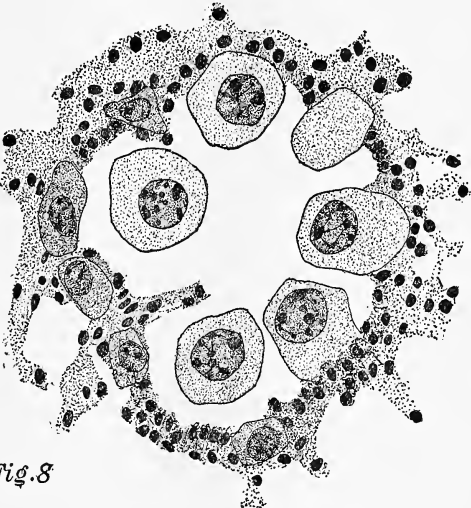


Fig. 8

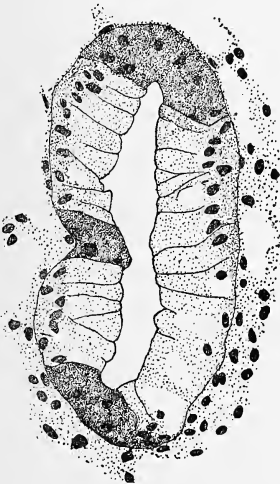


Fig. 10

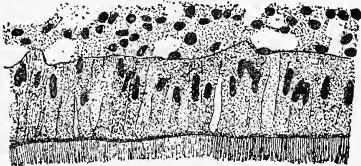


Fig. 9

my sub. sp. *vittata*, each one of which answers the requirements of a different sub. sp. of Fitch; on the other hand I have specimens which are unquestionably of different sub. sp., and occurring in widely separated localities which would be placed in the same sub. sp., and the same variety by Fitch's classification, clearly showing that the color of the pronotum is not of sufficient value on which to base sub-species. He made no provision for the black varieties and from his remark about the relationship of *C atra*, Germ., it is highly probable that he had none.

A careful study of about seventy-five specimens, embracing representatives from widely separated areas resulted in the adoption of the color marking of the clavus as a character constant for a given sub-species, and in the determination of specific characters as follows:

Size, medium; front strongly inflated, upper half black, lower half yellow; legs bright yellow, with lateral black lines.

Front rising abruptly from face at sides continuing in same plane as vertex above; upper half black; lower half, loræ and clypeus yellow, a black dot on center of clypeus. Vertex slightly, transversely depressed, anterior margin not distinctly carinated; suture between front and vertex indistinct. Pronotum bare, broadly, indistinctly, transversely wrinkled, wrinkles minutely striated, about twelve on the median line. Hemelytra with a fine short pubescence; first discoid cell wider than second second apical cell broad, nearly equal to third. Abdomen black or fuscous; legs bright yellow; a lateral line on front of femur, one on each side of tibia; all three joints of tarsi, and last segment of rostrum black. Length, four mm., width of pronotum about one and one-half mm.

Habitat: Iowa, Illinois (Forbes), Quebec, Canada, Ontario, Canada, New Hampshire, Massachusetts, Pennsylvania, New York, District of Columbia, New Jersey (Smith), West Virginia.

Sub. sp. I. *flava*. Anterior two-thirds of clavus yellow.

Var. *a*. Scutellum with a yellow spot

b. Scutellum black.

Sub. sp. II. *vittata*. Clavus yellow with an oblique black vitta through the middle.

Var. *a*. Pronotum with one yellow band anteriorly.

b. Pronotum with two yellow bands.

c. Pronotum entirely yellow.

Habitat: New York, Pennsylvania, Massachusetts, Connecticut, District of Columbia.

Sub. sp. III. *nigra*. Clavus entirely black.

Var. *a*. A yellow band on vertex, and one on face next to vertex.

b. Yellow bands wanting; entirely black above; legs darker.

Habitat: West Virginia, Pennsylvania, District of Columbia, Massachusetts, New York.

Specimens of *C. saint cyri* Prov., that I have from Quebec, Canada, belong to sub. sp. *I. flava*.

C. XANTHOCEPHALA GERM.

Germar's original description (Germ. Zeit. für die Ento., 1-189) is as follows:

Nigra, capite flavescente, frontis, fascia nigra, elytris maculis marginatibus hyalinis, puncta colloso ante apicem nigro, pedibus pallido-fuscae annulatis.

Habitat in Pennsylvania, Carolina, Zimmermann. One and one-half line lang. Kopf gelb, um der Scheitel dunkel, eine Quereinne auf der unterseite schwarz. Deckschilde schwarz, ein Fleck am Vorderrande vor der Spitze, ein anderer, der den ganzen Hinterrand einnimmt, glashell, letzterer mit einem schwarzen schwieligen Punkte vor der Vorderecke. Beine gelblich, braun geringelt.

This species is the most constant in size and coloration of any in the genus. From a study of over one hundred specimens representing every locality mentioned below, I have prepared the following description:

Small, brown or black without markings of any kind above; face with brown bands above, dark below with a distinct light band crossing the center; hemelytra very sparsely pubescent.

Front moderately inflated, light above with about nine transverse interrupted brown bands, band below these, and clypeus black, lorae, included portions of front, and margin of anterior coxal fossæ yellow. Vertex not strongly depressed; suture between vertex and front distinct. Pronotum with about nineteen fine indistinct wrinkles. Hemelytra strongly impunctured, very sparsely pubescent; second apical cell broad, irregularly wedge-shaped. Under side black; legs brown, spurs and spines tipped with black. Length, three and one-half mm., width of pronotum, one and four-tenths mm.

Var. a. Black above; a small white spot on center of costa.

b. Glaucus above.

Habitat: Mississippi, Arkansas, Texas, Louisiana, Maryland, District of Columbia, Virginia, Florida, Iowa, Pennsylvania, Carolina (Walker) and New Jersey (Smith).

C. OBTUSA, SAY.

Cercopis obtusa Say. Jour. Acad. Nat. Sci., Phila., IV, 339. (1825.)

Clastoptera achatina Germ. Zeit für die Ent., I, 189. (1839.)

C. testacea Fitch. Fourth An. Rep. N. Y. State Mus. (1851.)

C. pini Fitch. Fourth An. Rep. N. Y. State Mus. (1851.)

C. lineatocollis Stal. Eng. Resa Omk. Jord., IV, 236.

C. osborni Gillette. Hemip. Col., 71. (1895.)

C. stolidus Uhl. ?

C. undulata Uhl. ?

Say's original description (Coll. Writings, Vol. II, page 256) is as follows:

Head and anterior part of thorax pale, with three transverse lines; wings varied with brown and pale; body short, oval; head pale yellowish, an elevated, reddish-brown, transverse line between the eyes and before the stemmata; front with about nine parallel, equidistant, reddish-brown lines, which are interrupted in the middle and abbreviated in the cavity of the antennæ; antennæ placed in a deep cavity, beyond which the seta only projects, head beneath black; thorax pale yellowish before, reddish-brown and rugose with continuous lines behind, anterior edge elevated, reddish-brown, a reddish-brown transverse band on the middle; scutellum pale reddish-brown; hemelytra varied with fuscous and pale, generally forming a band on the middle which is more distinct on the costal margin, spot at tip and larger one at base; nervules dark-brown; feet black, joint whitish; tibiae and tarsi whitish, posterior tibia bi-spinous behind, of which one is very robust; length rather more than one-fifth of an inch.

The band of the hemelytra is sometimes indistinct, three brown dots near tip; female generally paler, with the abdomen whitish.

This species presents a remarkable number of quite distinct sub-species and varieties, and, owing to the fact that Say's description was of an extreme variety, a great deal of confusion has existed as to its limits, resulting in quite a number of these varieties being described as distinct species. I have appended these descriptions and have retained their names for the sub-species, except *testacea* and *pini*, which I find to be simply varieties of a sub-species of which the description of *osborni* is more nearly true; and it is therefore retained in preference.

The following synopsis of the species is a result of a summary of the different descriptions, and the study of 200 specimens representing every state given below with the exception of New Jersey. I am reasonably confident that with the possible addition of a few more varieties, it will stand the test of any farther discovery of material:

Large; front broad, flattish, with about nine bands above; second apical cell rectangular, elongate; pronotum finely, sharply wrinkled.

Front rising gradually from face at sides, making an obtuse angle with vertex above, upper portion light with about nine parallel, equidistant, transverse, interrupted, brown bands. Vertex very strongly, transversely depressed, carinated anterior margin prominent; suture between vertex and front distinct; ocelli situated near front margin.

Pronotum with about nineteen minute distinct wrinkles. Hemelytra minutely punctured, with a fine thickly set pubescence; second apical cell rectangular, elongate. First, discoid cell curved, narrower than second. Legs stout; spurs, spines and third tarsal segment tipped with black.

Length, four and one-half mm., width of pronotum, two mm.

Sub. sp. I. *obtusa*. Lower half of face fuscous or black.

Var. *a*. Dark; a distinct oblique, light band on hemelytra; pronotum, anterior half, light yellow, divided by a transverse brown band.

Habitat: Iowa, New Hampshire, Massachusetts, New York, Maryland, District of Columbia, West Virginia, Ontario, Canada.

Var. *b*. Light; same markings as above, only much lighter and less distinct.

Habitat: Iowa, New York, District of Columbia.

Var. *c*. Dark; hemelytra coppery; thorax without band; pronotum yellowish (*achatina*).

Habitat: Pennsylvania.

Sub. sp. II. *lineatocollis*. Lower half of face dark with a light band crossing the middle.

Var. *a*. Pronotum entirely dark; scutellum yellow; legs light with lateral dark lines. California.

b. Pronotum, posterior half dark, anterior half sulphur yellow; lines on femur and tibia broad, almost confluent. Colorado.

c. Pronotum light yellow, narrow brown band anteriorly; legs light, lateral line faint; dark band on clypeus reduced to a dot; hemelytra pale rufous, nervules brown, very distinct West Virginia, District of Columbia.

d. Pronotum entirely sulphur yellow; hemelytra dark coppery; legs brown. Maryland, District of Columbia.

Sub. sp. III. *osborni*. Face entirely light, bands on front obscure.

Var. *a*. Light olive green; scutellum sulphur yellow. Colorado, Wisconsin, West Virginia, District of Columbia.

b. Copper colored throughout (*testacea*). New York, West Virginia, District of Columbia, New Jersey.

c. Black; posterior margin of vertex, anterior margin of pronotum, costal margin of hemelytra, and legs yellow. (*Pini*) North Carolina, District of Columbia, New York (Fitch).

The following original descriptions may assist in recognizing the corresponding sub. sp. and varieties. Var. *a*, under each sub. sp., being its type, and of course the only one to which the description will entirely apply.

C. achatina.—(Germ. Zeit. fur Ento. Vol. I, 167.) Testacea; fronte nigra, elytris ante apicem fuscis, macula submarginali ante apicem nigra, femoribus medio fuscis. Hab. in Pennsylvania, Zimmermann. Two bis 2½ lin. lang, rothgelb oder grau gelb, stirn und Mittlebrust, bisweilen auch der Hinter-theil des Bauches schwarz. Deckschilde von der mitte weg bis vor die Spitze Schwarzlichbraun, doch bleibt ein Fleck am Seitenrande hell. Die Ader des vorderrandes fuhrst vor ihrer Spitze einen schwarzen Fleck.

C. lineatocollis. Stal. (Eng. Resa, Omk. jord. IV, 286) Caput dilute flavescens, verticis marginibus basali et apicali lineisque transversis frontis apicem versus longitrorsum impressæ nigrofuscis. Thorax postice

profunde angulatosinuatus, medio longitrorsum carinatus dilute flavescens, lineis pluribus transversis fuscis ornatum. Tegmina latitudine vix duplo longiora, sordide flavescente-pellucida, medio fascia antrorsum angustata et abbreviata albida, anterieus a linea, posticea fascia indistincta fuscis terminata, callo rotundato fere apicali ad marginem costalem nervisque apicalibus hic illic fuscis. Subtus nigro-varia. Pedis dilute flavescens, vitta femorum maculisque tibiaram nigro-fuscis.

C. osborni Gillette. (List Hem. Col. p 71) Female: face two-thirds wider than long, minutely, indistinctly sculptured; clypeus broad at base, gradually tapering to the pointed apex, one-fifth longer than broad, basal suture obsolete; loræ long, nearly as long and half as broad as clypeus; genæ narrow, outer margin concave beneath eyes, convex below loræ where they are very narrow, touching the clypeus at the broadest part; front but little longer than broad, superiorly very broadly and evenly rounded. Vertex very slightly transversely depressed, anterior margin carinately elevated, not longer at middle than at eyes. Pronotum transversely wrinkled, minutely scabrous, two distinct pits behind anterior margin near the median line, three-fourths wider than long, anterior curvature three-eighths of length. Scutellum finely and transversely wrinkled and minutely scabrous, longer than head and pronotum, twice longer than wide. Elytra with a fine, thickly set, golden pubescence, entirely finely, densely punctured. Color pale rufous throughout, tinged with olive green on pronotum and clavus, beneath more yellowish. Length, five and one-half mm. Described from two females. Large but somewhat narrower across the hemelytra than is usual in this genus.

C. testacea Fitch. (Ninth Rep. St. Ento. N. Y., 393.) Testaceous; scutel rufous; elytra with a polished callous-like black dot near the apex. Length, 0.20 inches.

C. pini Fitch. (Ninth Rep. St. Ento. N. Y., 393.) Black; head yellow, with a black band on the anterior margin of the vertex; thorax with a yellow band anteriorly; elytra with a broad hyaline under margin interrupted in the middle and a black callous dot near the apex. Length 0.14.

NOTE—I have been unable to obtain specimens of *C. undulata* and *C. stolidus* of Uhler from the West Indies, but from their descriptions I am very confident that they will be found to be varieties of *obtusa* also. So that, with the possible exception of *C. brevis*, Walker, this paper includes all the present known or described forms of the North American Clastoptera.

GEOGRAPHICAL DISTRIBUTION.

Quite a number of interesting facts have been brought to light through a comparative study of geographical distribution. Each species possesses a wide range, while some of the varieties are exceedingly sectional in their distribution. As a whole *obtusa* has the greater range, occurring from Massachusetts to California, and from Canada to Georgia, and probably to the West Indies. Sub-sp. I, *obtusa* is the most common form in the east and the only one found in the Mississippi valley,

while of sub-sp. II, *lineatocollis*, var. *a* and *b* occur only in California, Arizona and Colorado, and var. *c* and *d* have only been reported from Maryland and West Virginia. Sub-sp. III *osborni*, var. *a*, has a wide range, while var. *b* (*testacea*) and *c* (*pini*) are only found on the eastern coast from New York to North Carolina.

C. proteus, sub-sp. I, *flava*, is found throughout the northern half of the Mississippi valley and the eastern states up to Canada, while sub sp. II and III, *vittata* and *nigra*, are found only in Pennsylvania and the surrounding states. Both varieties of *xanthocephala* have the same wide range: the southern part of the United States, from Maryland to Iowa on the north to Florida and Texas on the south. *C. delicata* with all of its varieties ranges from Colorado to California, and from Utah to Arizona.

ECONOMIC IMPORTANCE.

As a whole they are of considerable economic importance. Although not usually occurring in sufficient numbers to be noticeably injurious, however, *proteus* has been reported as having done considerable damage to cranberry swamps in a number of instances. Their food habits have not been very accurately determined. In general they feed on the sap of trees and shrubs, occurring most abundantly in low places. They have been reported as occurring on the ash, oak, pine, alder, butternut, elder, blueberry, cranberry and some of the larger grasses and weeds.

SUMMARY.

The study of this genus just recorded only adds one more instance to the many giving evidence against the immutability of species. Here we have four species, of which the larger and lighter varieties are widely separated, and easily recognizable by constant and strikingly distinct color markings, while at the other end of the series are small dark forms only capable of separation and recognition by reference to structural characters rendered indistinct by deep coloration. To still more complicate matters, *proteus* excepted, they have intermediate light green or glaucous forms which so grade into each other in size and shade that it is only on structural characters in general, and the shape of the apical cells, in particular, that they can be separated.

The structural characters upon which the species have been founded have proved so constant, within measurable variations, for all the different varieties, that I am confident the species and the synonymical determinations will stand. The limitation of sub-species and varieties, while as accurate and complete as the 400 specimens of available material would allow, will doubtless undergo some expansion and correction with the accumulation of new and larger collections of material.

In conclusion I wish to acknowledge indebtedness to Messrs. Gillette, Lintner, Ashmead, Weed, Fernald, Goding, Skinner, Van Duzee, Sirrine, Maly and Gossard and Miss Beach for the privilege of examining material, and for other favors extended, and to Professor Osborn, in particular, for the use of his private collection and the department material, and for his invaluable counsel and advice.*

EXPLANATION OF PLATES.

PLATE XI.

Figure 1. *Clastoptera obtusa*, Say.

Color markings of Sub-species I. *obtusa*.

Showing color markings of faces.

Figure 2. *C. obtusa-obtusa*.

Figure 3. *C. obtusa-osborni*.

Figure 4. *C. obtusa-lineatocollis*.

Figure 5. *C. proteus-nigra* (variety b.).

Figure 6. *C. proteus* Fitch.†

Figure 7. *C. xanthocephala* Germ.‡

Figure 8. *C. delicata-lineata* (variety a.).

PLATE XII.

Venation of upper and under wings represented by one species from each genus as a type. The venation seems to be very constant within generic limits, as far as I have had opportunity to examine, with the exception of *Philenus* which either possesses two types or else there is another as yet unrecognized genus represented in our fauna.

Figure I. Wings of *Monecphora bicincta*, Say.

Figure II. Wings of *Philenus* sp.

Figure III. *Lepyronia 4-angularis* Say.

Figure IV. *Aphrophora quadrinotata*, Say.

Figure V. *Philenus* sp. °

Figure VI. *Clastoptera obtusa*, Say.

* This work has been done in the entomological laboratory of the Iowa Agricultural College, and submitted as a graduating thesis.

PLATE XIII.

- Figure 1. Leg of *Aphrophora quadrinotata*, Say, showing double row of spines.
 Figure 2. Leg of *Lepyronia quadrangularis*, Say.
 Figure 3. Leg of *Clastoptera proteus*, Fitch, showing single row of spines.
 Figure 4. Side view of *C. delicata*, Uhl., showing outline of face.
 Oblique dorsal view of same showing inflation of front.
 Figure 5. *C. proteus*, Fitch, same as above.
 Figure 6. *C. xanthocephala*, Germ.
 Figure 7. *C. obtusa*, Say.
 Figure 8. Venation of hemelytra, *C. delicata*.
 Figure 9. Same for *C. proteus*.
 Figure 10. Same for *C. xanthocephala*, Germ.
 Figure 11. *Clastoptera obtusa*, Fitch.
 1, 2 and 3; first, second and third apical cells, a and b; first and second discoid cells.

PLATE XIV.

- Figure 1. Abdomen of *Lepyronia quarangularis* Say, male, ventral view.
 Figure 2. Female, of same.
 Figure 3. Male, dorsal view.
 Figure 4. Abdomen of *Aphrophora parallela*, Say, male, ventral view.
 Figure 5. Female, ventral view.
 Figure 6. Same, dorsal view.
 Figure 7. Abdomen of *C. obtusa*, male, posterior view.
 Figure 8. Female, same view.
 Figure 9. Abdomen of *C. xanthocephala*, Germ., male, posterior view.
 Figure 10. Female, same view.

OBSERVATIONS ON THE CICADIDÆ OF IOWA.

 HERBERT OSBORN.

The members of this interesting group of insects, which contains the largest of our native Homoptera, have at least four representatives in the state of Iowa and it is the intention to call attention to these in this paper and also to put on record some observations regarding their habits and distribution which may serve as a basis for further investigations concerning them.

Cicada dorsata Say. One specimen of this large species in the collection of the Iowa Agricultural College from a student who stated that it was taken in Poweshiek county, is the only example indicating its occurrence in the state.

THE DOG-DAY CICADA.

(Cicada tibicen Linn.)

This is our larger common species, and one which, by its penetrating note, renders itself a conspicuous feature of the autumn weeks. First described by Linnè it has since received various appellations *opercularis*, Olivier; *pruinosa*, Say; *lyricen*, DeGeer and *canicularis*, Harris. This synonymy arises partly on account of the variability of the species. This variation is considerable when its range over a large part of the United States is considered, but within our own state this variation is somewhat limited. Specimens collected here generally conform closely to the description given by Say for his *pruinosa*.

Its distribution is quite general and I assume that it occurs throughout the eastern part of the state, at least, and in general over the timbered portions. I am assured by good observers, however, that there are places in the northwest part of the state where it is unknown. Specimens have been collected or received from many widely different localities.

In spite of its abundance and wide distribution our knowledge of its habits and life-history is very meager, though it is stated to require two years to complete its growth and to deposit its eggs in apple trees as one at least of the plants it may injure.

THE PERIODICAL CICADA OR "SEVENTEEN-YEAR LOCUST."

(Cicada septen-decem Linn.)

The "seventeen-year cicada" is doubtless the most interesting of all the Cicadas on account of its phenomenally long larval life. As is well known it lays its eggs in twigs of various trees and the larvæ entering the ground feed upon the roots of plants, and require a period of seventeen years to complete their growth. Two broods are represented in the state.

Brood V, Distribution.—In 1888, the locust year for the eastern part of the state, I secured, through the state crop service, reports from many of the localities which gave decidedly useful information with reference to limitations of the brood and comparison with previous occurrences. Records were received from over thirty counties and about ninety correspondents.

The limits of this brood have been outlined heretofore by Mr. Suel Foster, Dr. William LeBaron and Prof. C. E. Bessey.

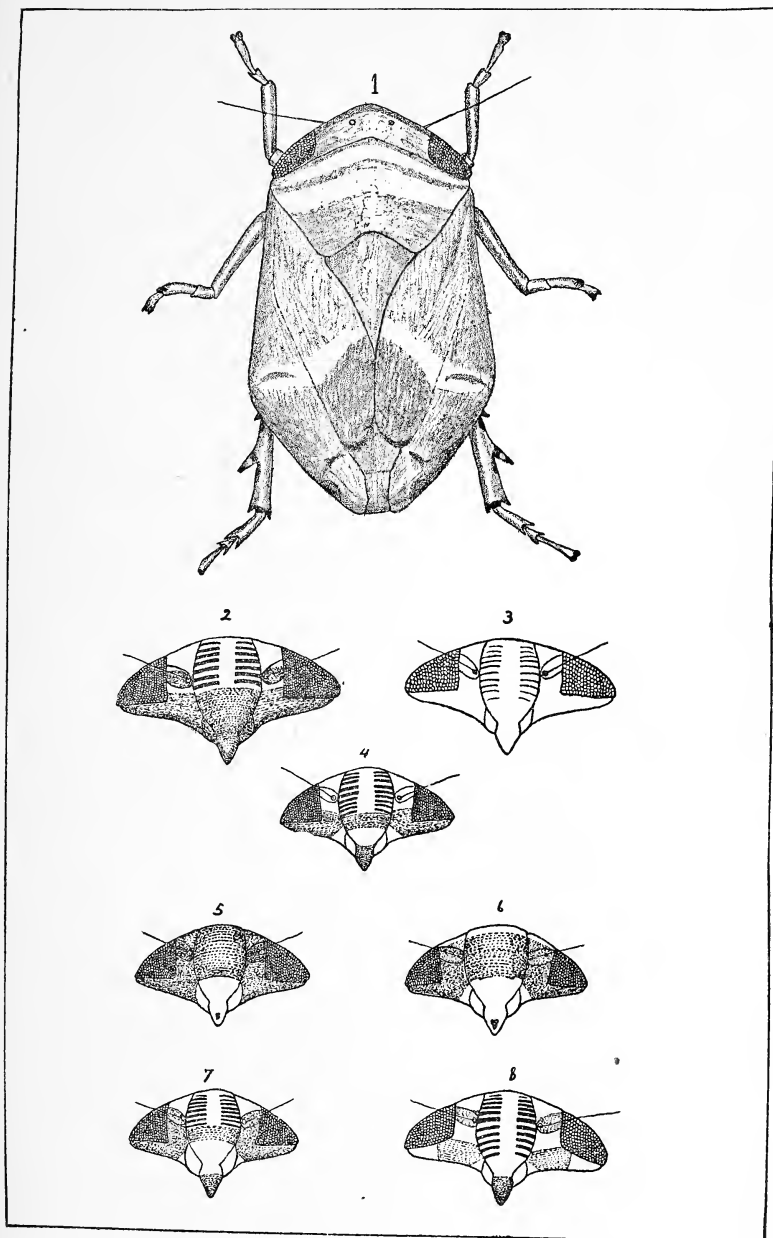
Dr. LeBaron (2d Rept. Ill. Insects p. 130) writes as follows:

"In the *Prairie Farmer* for July 29th, a brief outline of the locust range was published by Mr. Suel Foster, of Muscatine, Iowa, but in this outline, as Mr. Foster himself stated, many gaps were left undetermined. I have found Mr. Foster's outline to be, in the main, correct, and have filled, as far as possible, the gaps which he left. I will take the same starting point with Mr. Foster, namely, the junction of the Iowa River with the Mississippi in Louisa county, Iowa. Thence, in a northwesterly direction, following the eastern branch known as the Cedar River as far north as about opposite the mouth of the Wisconsin river. Thence east in about the same line of latitude to Lake Michigan, following the Wisconsin river so far as it lies in this line, thus leaving out the northernmost counties of Iowa and the two lower tiers of counties of Wisconsin." The rest of the description refers only to territory outside of Iowa.

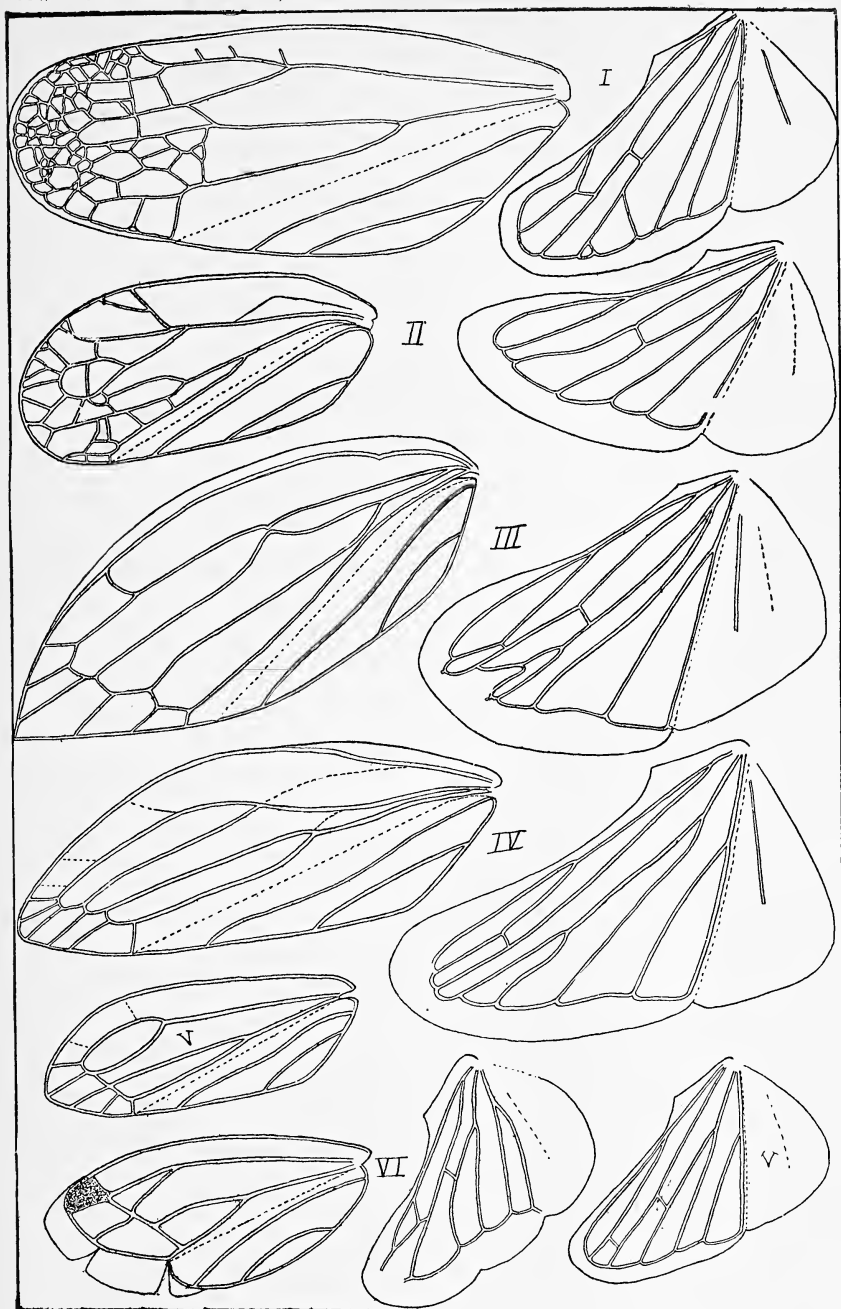
In 1878 at the time of the occurrence of Brood XIII in southern Iowa, Prof. C. E. Bessey, then of the Iowa Agricultural College, collected data for the determination of the boundaries of that brood and incidentally collected considerable information concerning the distribution of Brood V in the eastern part of the state.

His report upon this investigation appeared in the *American Entomologist*, Vol. I. N. S., p. 27. As there given the area included is considerably greater than that outlined by Dr. LeBaron. He does not seem to have noticed the record of LeBaron given above. His outline is as follows:

Starting at nearly the same point in Wapello, Louisa county, the line he draws extends more to the westward, including the western or Iowa branch of the Iowa river as far west as into Tama county, and considerable territory to the southward, including all of Johnson, more than half of Iowa and a portion of Poweshiek counties. From Tama county northeastward to the extreme northeast corner of the state including nearly all of Black Hawk, Fayette and Allamakee counties, and part of Bremer, Chickasaw and Winneshiek, with a possible extension westward so as to include all the counties to the north and east of Tama, though reference to his notes indicates some of the counties included, as Allamakee, Winneshiek, Black Hawk, Fayette and Bremer to be doubtful.



E. D. Ball, del.



E. D. Ball, del.

The counties reporting Cicadas for 1888 are as follows: Benton, Black Hawk, Buchanan, Clayton, Clinton, Cedar, Delaware, Dubuque, Iowa, Jackson, Johnson, Jones, Louisa, Muscatine, Scott, Tama. This shows only the counties reporting but does not indicate the extent or distribution in the counties, and this, for the border counties particularly, is quite important in fixing a definite boundary. I took pains therefore to locate the particular township from which the reports came, which was possible by examining the records at the secretary's office in Des Moines, and was thus able to locate the actual boundary usually within six miles at most, certainly within the limits of the ordinary flight of the insect.

The line of townships beginning at the Mississippi river in Muscatine county and naming those on the border line from which positive reports were received is as follows: Muscatine county, Fruitland, Cedar; Louisa county, Columbus City; Iowa county, York, Summer; Benton county, Saint Clair; Tama county, Clark, Geneseo; Black Hawk county, Spiny Creek; Buchanan county, Sumner; Clayton county, Cox Creek, Clayton.

For convenience sake we may carry our line through the towns and villages nearest this line and it will be approximately as follows: Fruitland, along south line of Muscatine to Columbus City, then along the west of the Iowa river till in Johnson county, then northwest to York Center, Iowa county and to near Ladora, then northeast to Blairstown, then northwest to Dysart, then northeast through Laporte City, Independence, Strawberry Point, Elkader and Clayton.

The area of natural timber corresponding for the most part with the valleys of the rivers and smaller streams, the distribution of Cicada may be pretty accurately expressed by defining them, and on this basis they may be said to occur in the valley of the Iowa river from Columbus City to west of Marengo, in the valley of the Cedar river and its tributaries as far to the northwest as Laporte City. In the Wapsipinicon to Independence, in the Maquoketa to Strawberry Point, in the Turkey to Elkader, and north on the Mississippi from south central Muscatine county nearly to McGregor.

Numerous reports not specially indicated, attest their abundance in all the central counties of this area and need not be specified but some which bear particularly upon the border line may be quoted here.

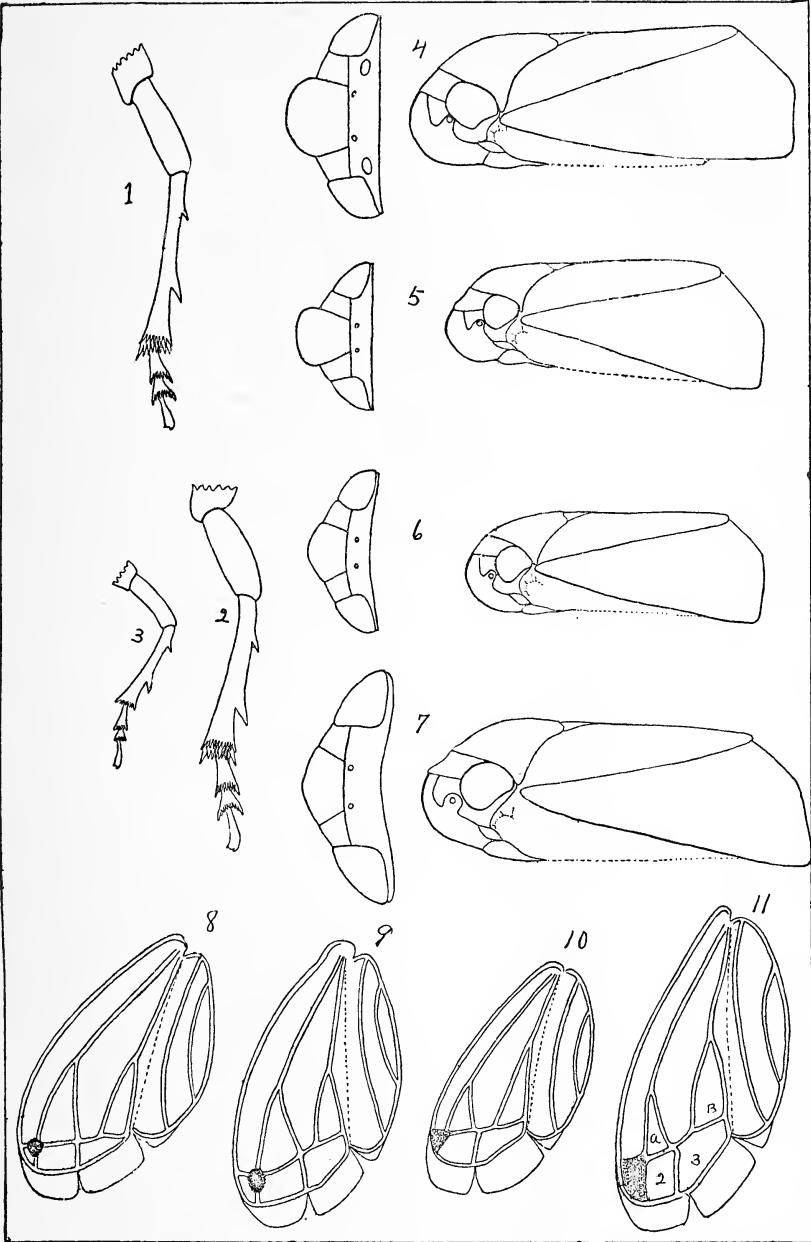
Mr. V. C. Gambell, a student in entomology whose home was at Winfield, in Henry county, saw no locusts there but a man in that vicinity reported hearing them and had seen one shell. This is rather uncertain testimony especially in view of absence of reports from this and the adjoining county to the north. If correct it shows a very feeble representation of the insect there. Mr. Gambell noticed in traveling on the Chicago, Rock Island & Pacific railroad from Brooklyn to Iowa City that the trees were injured, apparently by Cicada. If all due to Cicada this would carry the brood into Poweshiek county several miles further west than indicated by other reports.

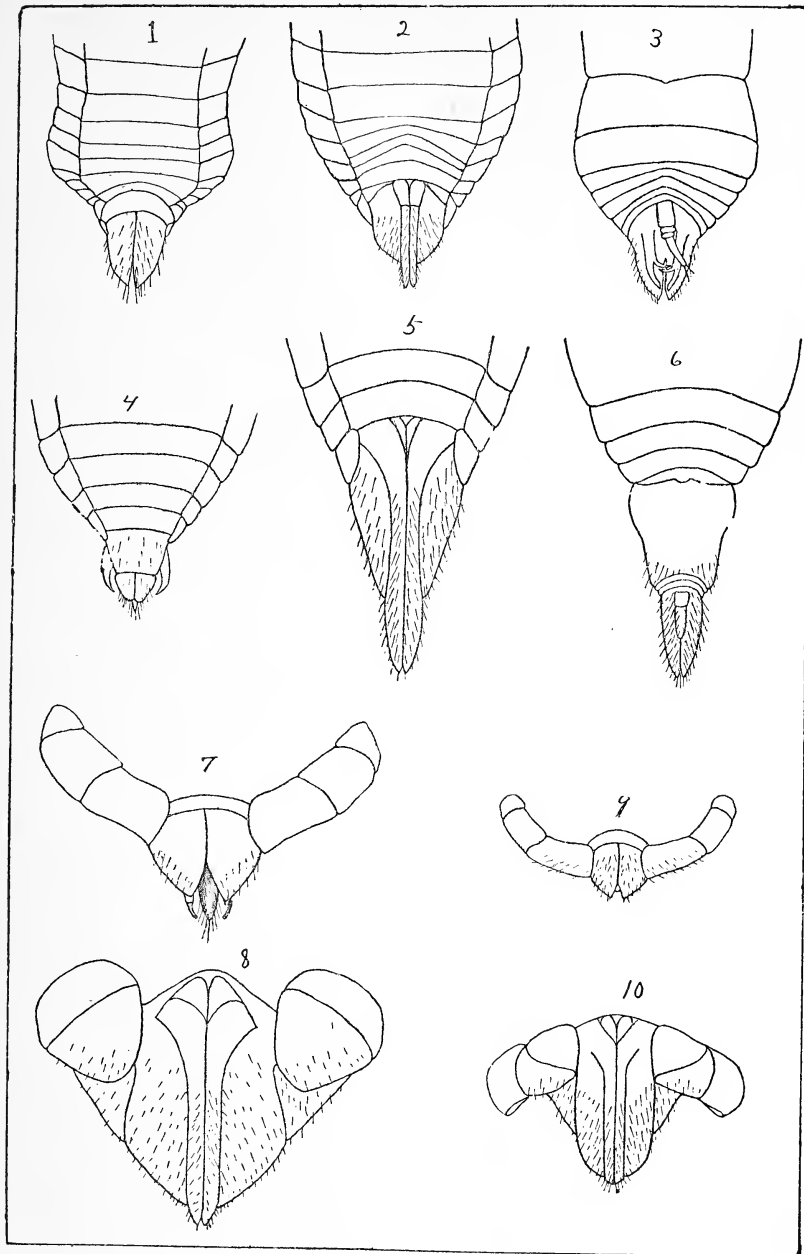
Mr. E. N. Eaton of Keota, in the extreme east of Keokuk found no locusts and no reports of them for that county.

Mr. P. H. Rolfs reports for the central eastern border of Tama county that there were no locusts and none for about five miles to the east of the county line, while Mr. F. A. Sirrine reports for a point about six miles further north that locusts were in Tama county, two miles west of the county line in Geneseo and Clark townships, but not in townships west so far as he could learn.

The following additional statements from correspondents have a special significance in determining the border line:

Louisa county, Wapello township, "None; a few in north part of the county." Columbus City, "Locusts present." In Keokuk county, Clear Creek township, "None here this year, but here seventeen years ago." Prairie township, "None yet; were here seventeen years ago." Garman township, "No locusts, last in 1877" [1878 Brood XIII probably]. Iowa county, York township, "Locusts in limited numbers in northeast third of this township." Poweshiek county, Malcom township, "None." Sheridan township, "None." Bear Creek township, "None. None seventeen years ago." Warren, "None yet, July 15th. Were here sixteen and seventeen years ago; second year in great numbers and did great damage to fruit trees and shrubbery." Chester township, "No seventeen year locusts to amount to anything; appeared in 1861 and 1878." [Brood XIII]. Black Hawk county, Spring Creek township, "Yes, and seventeen years ago." East Waterloo township, one correspondent says: "No, never here." Another says: "No. A few seventeen years ago." Fayette county, Westfield township, "None;





E. D. Ball, del.

none seventeen years ago." Eden township, "None." Jefferson township, "None within thirty-four years to my knowledge." Clayton county, Giard township, "None this year; a few seventeen years ago."

Brood XIII.—Professor Riley (1st Ann. Rept. State Entomologist of Mo.) mentions this brood as occurring along the southern border of Iowa, but does not specially define its limits. The 1878 occurrence was studied by Professor Bessey and the data collected enabled him to define the limits of the brood with considerable exactness (Amer. Entom., N. S. Vol. I, p. 27).

According to this record they occurred in the following counties: Van Buren, Davis, Wayne, Decatur, Des Moines, Henry, Jefferson, Wapello, Monroe, Union, Louisa, Keokuk, Mahaska, Marion, Warren, Madison, Adair, Cass, Iowa, Poweshiek, Jasper, Polk, Dallas, Marshall, Story, Boone, Greene, Hamilton, and they were assumed to occur in the counties embraced within the area encompassed by these, Clarke, Appanoose, Ringgold, Washington, Johnson, as indicated on his map, outline of which is shown. (Plate XV.)

On the recurrence of this brood last season (1895) I published requests in a number of state papers and also obtained from students and others, data covering as much territory as possible. The responses to the published requests were not so general as could be wished. In some cases many reports coming from the same locality, while a number of counties, where they must have occurred, furnished no reports.

Taking the counties reported in their order from the eastern border of the state they run as follows: Louisa, Keokuk, Poweshiek, Tama, Marshall, Story, Webster, Boone, Dallas, Madison, Union, Decatur, and for counties within the outer limits, Polk, Jasper, Marion, Monroe, Wapello, Jefferson, Van Buren, Lee.

The counties within this area which must, in all probability, have been visited, are Warren, Mahaska, Lucas, Wayne, Appanoose, Davis, Washington, Henry, Des Moines, while the doubtful ones are Johnson, Iowa, Hamilton, Greene, Guthrie, Adair, Ringgold.

Reports from Iowa and Johnson are quite positive as to their non-appearance in those counties, though it is possible our informants could speak for only a part of the area. There is also a probability that they occurred in Hamilton county, close to the Des Moines valley at least, if not in the Skunk.

In Greene, Guthrie and Adair they may have occurred in the valley of the Raccoon or tributaries.

By river valleys, then, which give really the more important distribution, we can say that they appeared in the Iowa valley at Louisa county, were absent or possibly scarce in Johnson and Iowa counties, but present in Tama and Marshall and north as far as Marshalltown; in the valley of the Skunk river from its mouth to Ames in Story county; in the valley of the Des Moines and its tributaries as far north as to near Fort Dodge and Lehigh, and in the Raccoon in Dallas county; also in the valley of the Grand river and its tributaries in Decatur, Union and Clarke counties.

Comparison of the points giving actual occurrence in 1895, represented on our map by square black spots, with the outline of Professor Bessey's map shows a reduction in most of the outline, with a slight extension in the Des Moines valley. These reports on the whole would suggest a reduction of the area, and many of the reports state a reduction in number of cicadas as compared with previous occurrences.

It is of course impossible with the records for even three or four occurrences to draw any conclusions as to the future history of the insect or assign causes to any apparent changes, still some suggestions as to probable influences may not be out of place as indicating lines of future observation and record. It is evident that many years must elapse before the problems connected with the species can be properly discussed.

Admitting that the broods in these respective areas have declined, it is interesting to inquire into the possible conditions affecting the perpetuation of the species.

It should be borne in mind that the great bulk of settlement in these parts of the state occurred between the appearance of the broods in 1854-1871 and 1861-1878 respectively, and that the settlement resulted in some important changes of the timber distribution. These changes took two forms, first a diminution of the natural timber belts along the streams from the necessities for fuel and in much less degree the clearing of limited tracts for cultivation. Second, an extension of the timbered area by the planting of groves, wind-breaks, orchards, etc., on the treeless portions. The former I believe not to have affected the area or quantity of timber very greatly, as it would be made good by the natural growth and extension and, especially as regards the Cicada, had, I believe very little influence. The

latter, though perhaps having very little effect as increasing the actual quantity of timber, seems to me a much more important factor in connection with the Cicada problem. These insects show a very decided tendency to deposit their eggs in young trees, and in 1871 and 1878 found abundant opportunity in the numerous young orchards and groves developed since their prior occurrence to satisfy this propensity, so much so that they must have in many places deserted in no small degree the natural timber areas for these artificial ones.

Now, it seems natural to suppose that depending normally for their food on roots common to areas of natural timber they should have been met with a deficiency of such food in many of the localities to which the adults had flown to deposit eggs, and consequently have failed to develop and mature.

Such an influence will, of course, not be permanent and if this be the only factor of importance Cicada should recuperate in the future.

It has been my privilege to observe personally the occurrences of both these broods since 1871, and I hope to have the opportunity to observe many of their generations in the future.

TIBICEN RIMOSA, SAY.

This species, which may be considered as belonging more particularly to the northern and western fauna, is represented in this state by a depauperate form and in the northern and western portions by a form more closely approaching the western type.

It was described by Thomas Say in Proc. Acad. Nat. Sci. for 1830, p. 235, who ascribes it to the Missouri and Arkansas and says further "Mr. Nuttall presented me with two specimens which he obtained on the Missouri, and I found one on the Arkansasaw."

While Mr. Nuttall's specimens may have been secured on Iowa soil the probability seems strongly in favor of a location further west in the then extensive territory of Missouri.

But slight mention has been made of the species since that time and if it is found in the Mississippi valley as a species at all common, it has failed to receive due mention. It is collected in abundance in the Rocky Mountain region, and I have numerous specimens from Colorado and New Mexico.

Aside from the depauperate form to be mentioned further, I have specimens from Tama county, collected by Mr. F. A.

Sirrine, of the larger form approaching typical examples also from Worth county, collected by Mr. S. W. Beyer.

It occurs somewhat commonly in the northwest part of the state and probably is responsible for some of the reports of seventeen year Cicada emanating from that quarter. Mr. E. D. Ball, a graduate of the Agricultural college and whose home is at Little Rock, Lyon county, states that it is found quite abundantly throughout the prairie regions of the northwest part of the state and that it was more abundant in the 70's, before the prairies were broken up, than at present. He gives some interesting observations regarding its habits, the most striking being that it occurs on prairie land remote from timber, thus indicating a habit quite different from the other members of the genus. He states that in herding cattle on the ranges years ago, he has seen them as many as four or five to the square rod of grass in localities where the nearest trees were ten miles away and these only bush willows fringing a stream. During the summer of 1893 he carefully observed them in a lot in town. The lot was bordered on two sides by a double row of trees, box-elder and maples. At any time plenty of the cicadas could be found or heard in the grass, but careful searching failed to find a single one or any indications of egg deposition. They occur more abundantly in the rich upland grass at the foot of a hill or bordering a meadow, a situation equally favorable to the growth of certain prairie weeds, notably the "shoestring" or Lead plant, *Amorpha canescens*, which has a very tough woody stem, a plant which was particularly abundant in the lot above mentioned. The cicadas were frequently seen on this plant, but no eggs were found. They appear the latter part of June and only live for two or three weeks at most.

The form of this species which occurs at Ames is much smaller and with more extensive orange markings than in the western forms; it is by no means common and no observations have been made as to its breeding habit here. It is so different from the larger Rocky Mountain form that were it not for the intermediate forms occurring throughout the range of the species as a whole, there would be little question as to its being recognized as distinct. This form agrees with the one described by Emmons as *noveboracensis*.

MELAMPSALTA PARVULA SAY.

This interesting little species has been taken once at Ames and this is, so far as I know, the only record of its occurrence in the state. It is a more southern form, being credited to the southern states as far north as southern Illinois and central Kansas. Very likely it may be found occasionally in the southern part of the state when collectors become more plentiful.

Any addition to these records will be gratefully received and duly credited in future records.

BIOLOGIC NOTES ON CERTAIN IOWA INSECTS.

HERBERT OSBORN AND C. W. MALLY.

The following notes are extracted from Bulletin 32 of the Iowa Experiment Station, and embrace such portions of work upon certain injurious insects as have a biologic interest. We are indebted to the Experiment Station for the use of the figures.

THE GROUND CHERRY SEED MOTH.

(Gelechia sp.)

Our attention was called to this insect by Dr. J. C. Milnes, of Cedar Rapids, who reported it as very destructive on wild ground cherries under cultivation; writing further, that this cherry being very prolific and of excellent quality would be a desirable garden plant were it not for the great injury from this pest. The specimens sent contained the insect in the pupa stage.

Cultivated ground cherry at Ames suffered from similar attack, and the pest seems likely to occasion much loss.

Examination of wild ground cherries in the vicinity of Ames revealed a considerable injury from the pest, and steps were taken to secure the early stages and determine as fully as possible the habits of the insect.

Out of 1,000 berries examined 130, or 13 per cent were infested. All of these infested berries contained the pupæ enclosed in a white silken cocoon which filled most of the cavity of the berry, the seeds being entirely devoured. Near the stem end of the berry and opposite the head of the pupa was an opening presumably prepared for the emergence of the moth.

Observations on these berries would favor the conclusion that the larvæ develop within a single berry, no injured berries being found which did not contain pupæ. However, two berries were found with an opening on the side and containing well developed larvæ with very little of the inside of the berry devoured, suggesting that the larvæ, under exceptional conditions migrate from a berry of insufficient food material to a fresh one.

But very few larvæ were found and these during the last week in September. They were at that time mature and apparently ready to pupate; so of the early molts and even of the full grown larvæ we cannot give a satisfactory description. Those observed were rather contracted, spindle-shaped, whitish, with a reddish-brown head, sparsely haired.

Pupation occurs during last two weeks of August and is in nearly all cases completed by the last of the month.

The pupæ are dark brown, six mm. long, and no distinctive characters that would separate them from related species were detected. The cocoon is thin but of tough, close woven silk. In forming the cocoon the larva attaches itself to the blossom end of the berry by means of the caudal prolegs and then builds the cocoon which practically fills the cavity of the shriveled berry.

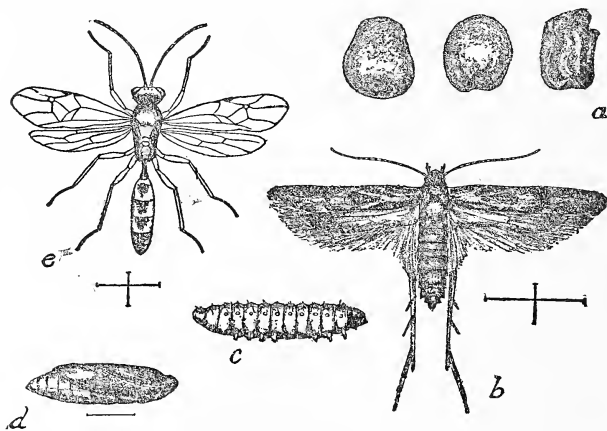


FIG. 1. (*Gelechia* sp.) a, injured berries. b, moth. c, mature larva. d, pupa. e, parasite *Centeterus suturalis*.

Moths first appeared October 3d, so the period of pupation may be stated as from two to three weeks.

The moth shown at *b* in Fig. 1 is of a gray color with darker spots on the wings. It closely resembles *G. quercifoliella*.

Out of the 130 berries containing pupæ mentioned above we secured four specimens of moths. This low per cent of adults is due to the fact that a large proportion of the pupæ, over 100, were destroyed by a fungus, apparently quite similar to *Sporotrichum*, and of the remainder a number were attacked by a Hymenopterous parasite (*Centeterus suturalis* Ash), seven of which issued prior to September 24th.

The fungus was not observed to attack healthy berries, always making its appearance after the hole had been made near the stem, and, while it seemed to develop in the tissues of the berry, there seems scarcely any doubt but that it is a parasite of the insect. Some of the Hymenopterous parasites issued from berries showing fungus growth, so that it would appear possible for these to resist the fungus, even when pupæ were infected with it; that is, supposing the fungus to infest primarily the *Gelechia*. Doubtless a parasitized larva would be a more easy victim of fungus attack.

The appearance of moths so late in the season, the impossibility of their producing another brood, and the improbability of their depositing eggs in any situation where they would winter and assure the larvæ access to their food plant the following spring, almost forces us to the conclusion that the moths hibernate and deposit eggs when ground cherries bloom the following season. This view is strengthened by the fact that a specimen was captured in an office room of one the college buildings December 7, 1894. Nevertheless, so long an existence of the adult for so delicate a lepidopterous insect seems doubtful, and the possibility of some pupæ hibernating or of a spring brood of larvæ, even in some situation different from the berries of *Physalis*, must not be overlooked.

This species, as already intimated, very closely resembles *G. quercifoliella*, and it was so determined with some doubt by Mr. Marlatt from specimens sent to Washington for identification. The fact that it affects a totally different plant indicates it to be quite distinct from that species. It is certainly different from *physaliella* as described by Chambers, and has a totally different larval habit, that species being said to mine the leaves of *Physalis* in September, to pupate in leaves and rubbish on the ground, and to issue as adult in April. Still another species described as *physalivorella* was thought possibly to represent our form, though no record of its larval characters or habits were accessible. Mr. Marlatt has, however, kindly

compared our specimens with three specimens of *physalivorella* in the National museum, and states, "these are very distinct from your specimen." "The latter agrees quite well with *G. quercifoliella*, but may be a distinct species."

From this it seems most probable that this insect is undescribed, but we prefer to leave the technical description to some specialist in this group of delicate and interesting moths.

ON THE EARLY STAGES OF THE IMBRICATED SNOUT BEETLE.

(*Epicaerus imbricatus* Say.)

While this species has been recognized as a pest since its first economic treatment by Walsh in 1863, our knowledge of its life history has remained as meagre as at that time, nothing being known as to its early stages, except the record of egg laying by Professor Forbes.

This led us, on receiving specimens of the beetle with the report of their injury to strawberry plants, to attempt their breeding upon this food plant. While we did not succeed in tracing the full history of the species, the securing of eggs and the partial development of the larvæ, and the possibility that this clue may assist in the further elucidation of its history is our excuse for presenting this fragmentary account.

On May 14, 1895, the adults were placed on a strawberry plant having three or four open leaves and a number of small berries. They immediately crawled up the stems and soon began feeding upon the leaves, cutting a crescent corresponding to a line described by the end of the snout. The crescent was apparently quite uniform but soon became irregular when the beetle had to move in order to reach the tissue; so in reality there is no regularity in devouring the leaf and finally nothing is left but the veins and a few angular fragments of leaves. By the following day the effect on the leaves was quite apparent, the beetles eating rapidly, and by the 20th the leaves were all devoured except a few dry, curled pieces and the stems. They did not attack the berries, but in some cases ate the sepals at the base.

The beetles began pairing the first day and continued for five or six days. No eggs were observed till the 21st when a number of small, white, glistening eggs were found under a fold of a leaf and as no folded or dry leaves had been left on the plant these eggs had certainly been deposited by the *Epicaerus*. On the 22d another leaf containing eggs was found

and these, with those previously found, were placed by a fresh leaf that had been carefully freed from all matter that might possibly contain eggs of other species, and the beetles removed to avoid possibility of their injuring the egg. The eggs appeared in all cases to be protected by a fold of leaf carefully glued down.

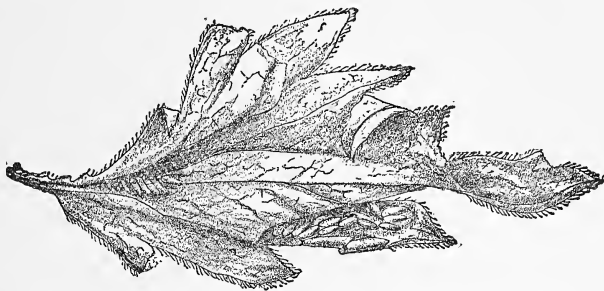


FIG. 8. *Epicaerus imbricatus* eggs. (Drawn by Miss King.)

Forbes¹ says of *Epicaerus* that they "were found by experiment to feed freely on pear leaves, and also to lay their eggs upon these leaves, concealing their deposit by gumming another leaf to the surface."

The eggs are 1.3 mm. long, glistening white, nearly cylindrical, sometimes very slightly curved, the ends broadly rounded, the surface smooth, transparent and the shell very thin.

The first larvæ to hatch escaped before being seen, the empty shells being first noticed on the 30th. Hatching therefore occurs within ten days from time of deposition. Other eggs isolated and kept under close observation showed that the larvæ immediately work their way into the ground and these observed in root cages, during the following three weeks, could be seen to move about among the roots and as they very evidently increased in size and appeared to thrive it is safe to say that they fed upon the roots of the strawberry plant.

The death of the plants in the root cages and the loss of the larvæ unfortunately brought the observation to an end.

The young larvæ are two mm. long, without any trace of eyes or legs. They are yellowish-white in color, the head from above oval with a few strong bristles and the mandibles very conspicuous. The maxillary and labial palpi are short, stumpy and in the living larvæ stand out rather prominently from the under side of the head. The body segments are provided with a few small hairs.

¹ Sixteenth Report State Entom., Ill. p. 76.

Adult beetles have been observed in autumn, as early as August, but the probability is that only one brood occurs each year, the adults surviving the winter.

This fragmentary result enables us to say with certainty that the eggs are deposited in dry and folded leaves of the food plants of the adults and that the larvæ immediately enter the ground to feed upon the roots. To this extent they show what measures of control must be adopted for this insect.

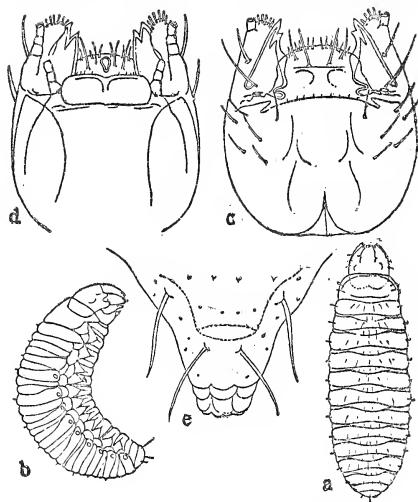


FIG. 9. *Epicaerus imbricatus*. a, b, young larva, back and side view. c, head above. d, head below. e, terminal segment. (From drawings by Miss King)

THE COSMOS WEEVIL.

(*Baris confinis* Lec.)

This weevil, Fig. 4, was found September 1, 1895, to work very extensively in the root-stocks and the base of the larger branches of *Cosmos bipinnata* causing the ultimate destruction of the plant. The presence of the insect is first manifested by

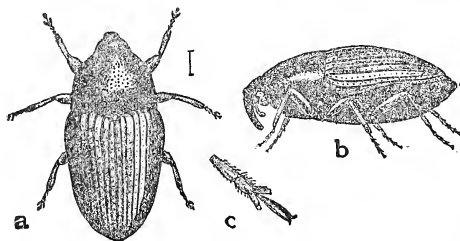


FIG. 10. *Baris confinis*. (Drawn by Miss King.)

the breaking off of the larger branches. By examining the base of these branches, and especially the root-stock, it will be

found that numerous white larvæ and pupæ about one-eighth inch long are present and working in the woody tissue of the plant. They make small tunnels, packing the borings around them much as does the potato-stalk-weevil. They pupate in these tunnels and emerge as a small black beetle.

The adult when first formed is white and takes on the black color gradually, beginning on the head and thorax and then extending backward to the scutellum and base of elytra and then gradually over the whole body.

The adults are quite active but drop to the ground as soon as disturbed and remain very quiet for some time.

Specimens of the adults kept on plants under observation in the laboratory worked in the young tender tissues, either eating into the terminal portions or into the stems at the axils of the leaves, almost burying themselves and finally causing the small leaf or branch to break down, as do the larger branches. They were not confined entirely to the parts just mentioned but would eat into the little leaflets as they were expanding, thus preventing their complete opening.

One individual was found boring into the end of a broken stem making its way into the pith and almost disappearing in a short time. It remained in that position for some time. Thinking that it might be a female and that the eggs were being deposited, the cavity was examined at the end of four or five days, but no eggs were found. This adult was placed on a growing plant and soon began feeding in the young tissues as stated above. On one small plant in the laboratory the young leaves were so badly eaten into that the plant died in a short time.

One specimen was taken while collecting in the woods August 31st. So the species undoubtedly infests other plants besides the one recorded above.

Nothing can be stated concerning oviposition and the early larval stages. As stated above, numerous fully grown larvæ and pupæ were found in the root-stock and base of the larger branches September 1st. A few fully colored adults were found a few days later. One root-stock was isolated during the second week in September and adults kept gradually issuing until about the middle of October. From this one root-stock as many as twelve to fifteen specimens issued besides the numerous larvæ and pupæ that were removed for the purpose of examination.

Since no eggs were deposited by the specimens kept under observation and adults were still very active after the plants

had all been killed by frost, it is quite safe to say that they hibernate and deposit eggs the next spring, there probably being but one brood each year.

A nearly related species, determined at the Division of Entomology, U. S. Department Agriculture, as *Baris dolosa* Casey, was bred in small numbers from the same stems. It was thought to be the same and differences in appearance due to imperfect maturing, but there is a decided difference in form of thorax and it seems probable that both species breed in the same plant and with practically the same life history.

DESCRIPTIONS.

Larva: Fig. 11, a. The fully grown larva is about 5-32 in. long and 1-16 in. diameter, and a yellowish-white color; head light brown, mandibles reddish-brown; legs represented by mammiform protuberances. The body tapers somewhat toward posterior end, the last segment usually showing four bristles.

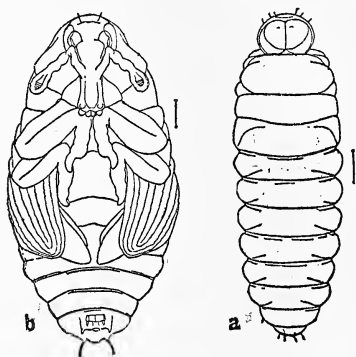


FIG. 11. *B. confinis*. a, larva. b, pupa.

Pupa: Fig. 11, b. About the same length as larva, but comparatively wider. Head (from beneath) fits closely to the body, eyes not especially prominent; antennæ wide in proportion to the length, normally not projecting beyond the sides of the thorax, club conspicuous, usually somewhat denser in appearance. Snout reaches base of first pair of legs and shows small, roundish portions at tip corresponding to the mouth-parts. First and second pair of legs clumsy in appearance; joints of the tarsi indicated, the last one distinctly curved; third pair of legs hidden, only a slight portion being visible along the inner margin of the hind wing-pads. Four abdominal segments visible for their entire width. The last segment usually has two apical bristles and a group of small spiny processes.

Adult Fig. 10. (a, dorsal view; b, side view; c, tarsus.) Widest at base of elytra and tapers strongly toward either end; shining black, glabrous; numerous medium sized punctures on the thorax and between the striæ of the elytra. Snout about 1-24 inch long, curved, usually extending directly downward, but sometimes drawn backward or slightly projected forward. Thorax narrows perceptibly toward the head. Tarsi strongly pubescent beneath, claws strongly curved, diverging. Elytra emarginate at tip, making the tip of abdomen more distinctly visible from above.

REMEDIES.

Collecting and burning the old root-stocks and stems in early autumn will be the most effective treatment that can be suggested from present knowledge of the species.

AN INSECT OCCURRING IN WATER TANKS AND RESERVOIRS.

(*Chironomus sp.*)

Early in July I received some specimens of a slender red larva from Boone, with the following letter:

Professor Osborn:

DEAR SIR—Enclosed I send a sample of the worm that appeared in our city water about a week ago in countless numbers. Would like to know what they are and where they would be likely to come from. The water we use comes from a 3,000-foot well, but about two weeks ago our pumps failed and we were supplied with water from a forty-five foot vein owned by the C. & N. W. Ry. Co., and pumped to our reservoir through a hose.

Yours truly,

E. E. CHANDLER,

Chairman Water Committee.

Boone, Iowa.

The larvæ were evidently *Chironomus*, and in replying to the letter it was so stated and that in themselves they could be considered harmless, though of course the presence of masses of such ugly looking creatures would be objectionable, and if dying in the water they might become a source of pollution. Also that the larvæ must have gained access to the water from the eggs of the adult mosquito-like insect being deposited in the reservoir or the mains by which it was filled. They could not be derived from a deep well. It was suggested that provision be made to exclude the insects from the water to prevent deposition of eggs.

The larvæ (Fig. 12) *a* and *b*, which are an inch or a little more in length and of a light red color with green reflections on the sides near the head, construct a tube at the bottom of

the water in which they live, and in this remain protected and from it extend themselves to obtain food. The food is for the most part apparently minute aquatic organisms, algæ, etc. Their presence might be considered a means of clearing water of such matter did they not at times become so numerous as to prove an element of danger.

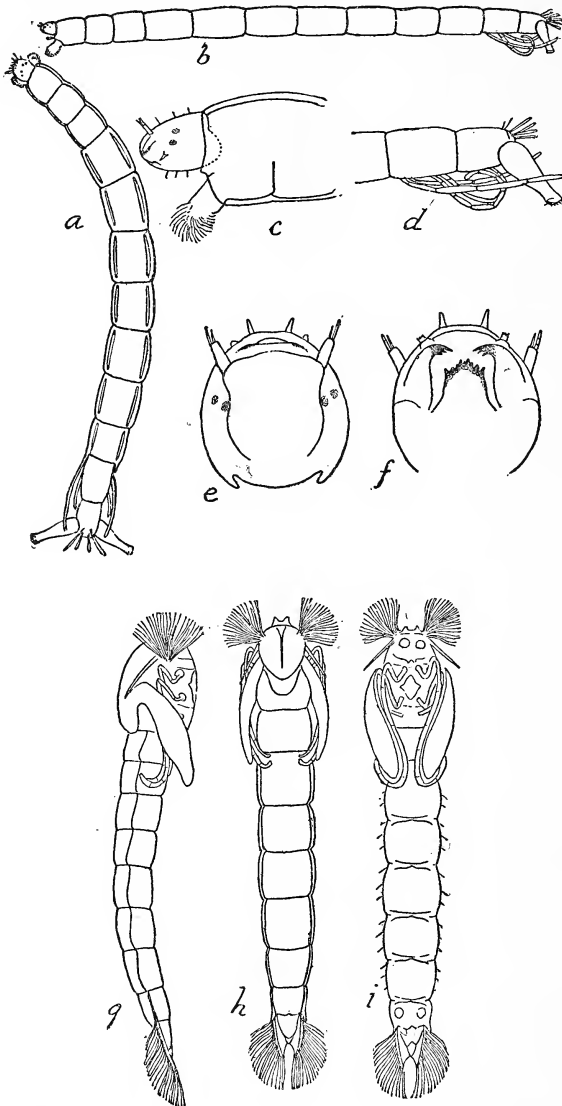


FIG. 12. (*Chironomus* sp.) a, larva, dorsal view. b, side view. c, head and first segments of body. d, terminal segments of body showing appendages. e, upper surface of head. f, lower surface of head. g, side. h, dorsal. i, ventral view of pupa. (Original, drawn by Miss King.)

Later in conversation with Mr. G. W. Brown, a civil engineer of Boone, it was learned that the water was pumped into a large cement-lined reservoir which contained the larvæ in immense numbers and was without question the point where the eggs were laid, it being exposed to easy access by insects. It appeared also that the larvæ were drained into the mains at times when the reservoir was low, doubtless causing strong currents over the bottom. Specimens have also been received from Des Moines.

When mature they change to a delicate pupa (Fig. 12, *g*, *h*, *i*,) and then rise to the surface of the water and soon the adult insect escapes from a slit along the back of the pupa case.

The adult is a delicate mosquito-like insect (Fig. 13.) belonging to the genus *Chironomus* but it cannot be referred to any of the described species and the present state of the classification of this genus is such as not to warrant us in giving it a scientific name or description.

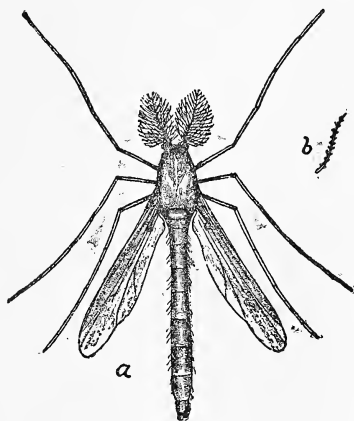


FIG. 13. (*Chironomus* sp.) *a*, adult male. *b*, antenna of female. (Original).

The insect is of interest at this time because of the great number of water tanks and reservoirs established, not only in cities and towns, but on many farms, and the probability of its frequent occurrence where these are open to visits of the adults.

Exclusion of the adults, where practicable, may be accomplished by the use of ordinary mosquito netting or wire gauze. Where this is impracticable the providing of an inlet to distributing pipes that will draw water from a few inches above the bottom of the reservoir (which might further be protected by a fine screen) will, it is believed, avoid the distribution of the worms in the mains.

CONTRIBUTIONS TO A KNOWLEDGE OF THE THRIPIDÆ OF IOWA.

ALICE M. BEACH.

This paper represents the results of a study of some of the Thripidæ of Iowa, and is based upon an examination of material found in the collection of the Iowa Agricultural College, some specimens kindly loaned by Miss Emma Sirrine, Messrs. F. A. Sirrine and C. W. Mally, and some in the writer's own collection. Descriptions of seven new species and three new varieties are herewith presented, including a new species of Phlœothrips described by Prof. Herbert Osborn. The descriptions are preceded by an artificial key, arranged to aid in the identification of all the described Iowa species known to the author. The table for the determination of genera is substantially that found in Comstock's Introduction to Entomology, pp. 125-127. The writer is indebted to Mr. Pergande for an outline of the characters of Euthrips, and is under special obligations to Professor Osborn for valuable aid in the prosecution of this work which has been done in the Entomological Department of the Iowa Agricultural College.

TABLE FOR DETERMINATION OF GENERA.

- A. Last abdominal segment in both sexes elongated, narrow, tubular; both pairs of wings similar, veinless, margins equally ciliated; maxillary palpi two-jointed; borer in female absent.....Sub-Order I. Tubulifera.
- B. Contains but a single familyFam. I. Tubuliferidæ.
- C. Contains but a single genus.....Gen. I. Phlœothrips.
- AA. Last abdominal segment not elongated and tubular in both sexes; both pairs of wings unlike in structure, front wings always veined; margins unequally ciliated; maxillary palpi three-jointed; borer in female present.....Sub-Order II. Terebrantia.
- B. Females with borer curved upwards.....Fam. II. Stenopteridæ.
- BB. Females with borer curved downwards...Fam. III. Coleoptraticidæ.

FAM. II. STENOPTERIDÆ.

- A. Body above netted with elevated lines.....Gen. 2. Heliothrips.
- AA. Body above smooth.
 - B. Abdomen clothed with silky hairs; apex conical, formed alike in both sexes.....Gen. 3. Sericothrips.
 - BB. Body smooth; apex of abdomen unlike in the two sexes.
 - C. Prothorax produced in front, and narrowed.....Gen. 4. Chirothrips.
 - CC. Prothorax not produced in front and narrowed.
 - D. Last segment of abdomen with a pair of spines in female; male, wingless.....Gen. 5. Limothrips.
 - DD. Last segment of abdomen unarmed.
 - E. Last two segments of antennæ shorter than the sixth segment.....Gen. 6. Thrips.
 - EE. Last two segments of the antennæ longer than the sixth segment.....Gen. 7. Belothrips.

FAM. III. COLEOPTRATIDÆ.

- A. Antennæ with nine distinct segments....Gen. 8. Melanthrips.
- AA. Antennæ apparently five jointed, the last four segments being minute and compact
 - B. Body somewhat flattened; meso-metathorax broad; front wings without fringe on costal border, and with four distinct cross veins; males with lateral abdominal appendages.....Gen. 9. Coleothrips.
 - BB. Body cylindrical, mesothorax and metathorax constricted, wings rudimentary.....Gen. 10. Aeolothrips.

SYNOPSIS OF IOWA SPECIES.

GENUS PHLÆOTHRIPS, HAL.

- A. Proximal joint of anterior tarsi armed with a tooth on inner side ..1
- AA. Proximal joint of anterior tarsi unarmed.....2
 - 1. With postocular bristle; three bristles on each side of prothorax; antennal joints 3-6 yellow.....*verbasci*, Osb. Without postocular bristle; a single bristle at each posterior angle of prothorax; antennal joint 3 and base of joint 4, sometimes base of joint 5, yellowish.....*nigra*, Osb.
 - 2. Black; head slightly longer than wide; tube three times as long as wide.....*caryæ*, Fitch. Purplish-black; head one and one-half times as long as wide; tube twice as long as wide.....*malii*, Fitch.

Phlæothrips verbasci, Osb.

Description follows this paper.

Phlæothrips nigra, Osb.

Can. Ent., Vol. XV, p. 154 [1883].

Phlæothrips caryæ, Fitch.

[Third Report.] Trans. N. Y. State Agr. Soc. for 1856, Vol. XVI, p. 446.

Phlæothrips mali, Fitch.

[First Report.] Trans. N. Y. State Agr. Soc. for 1854, Vol. XIV, p. 806.

GENUS HELIOTHRIPS, HAL.

This genus is represented in the collections by a single species, *H. hæmorrhoidalis*, Bouché. It is probable that *H. draccenæ* Heeger also, which occurs frequently in hothouses in this country and in Europe, is found in this state. These two species may be separated as follows:

Fuscous, apex of abdomen ferruginous; antennæ and feet pale; first and second joints of the former fuscous, sixth joint black.....

..... *hæmorrhoidalis*, Bouché.
Yellowish-brown; wings white, sub-fasciate with brown... *draccenæ*, Heeger.
Heliothrips hæmorrhoidalis, Bouché.

Naturgeschichte der schädlichen und nützlichen Garten-Insekten, p. 42 [1833].

Heliothrips draccenæ, Bouché.

Sitzungsb. d. mathem.—naturw. Klasse d. Wissensch., Vol. XIV, p. 365 [1854].

GENUS SERICOTHRIPS.

One species, *Sericothrips? perplexa*, containing representatives of the male sex only, has been doubtfully referred to this genus. This species possesses well marked characters, evidently of generic importance, which do not accord with those of any genus of this family with which I am familiar. They are as follows: Head somewhat flattened or depressed and produced in front with the ocelli placed very far forward; fourth antennal joint decidedly longer than the third, apex of abdomen in male formed like that of females of this family. In Burmeister's Handbook of Entomology, Vol. 2, p. 413, the genus *Sericothrips* is characterized as having the abdomen covered with silky hairs, head hidden up to the eyes in the thoracic segment and the tip of the abdomen formed alike in both sexes. In the enumeration of species, the same authority records but a single species, hence it may prove that a more extended knowledge of allied forms will make it necessary to enlarge the limits of the genus, therefore it seems best to place this species here provisionally rather than to erect a new genus.

Sericothrips? perplexa, n. sp.

Male: Length, 1.33–1.55 mm. General color fuscous; legs and annulus on antennæ yellowish; thorax tinged with yellow-ferruginous; abdomen

except apex, varying from pale to deep fuscous; anterior wings subfuliginous, clearer at base. Form slender; bristles and spines short, inconspicuous; head, from dorsal view, subpentagonal; antennæ seven-jointed, approximate; ocelli placed very far forward toward front border of head; posterior angles of prothorax bisetose; spines on cubitus 15-16, arranged in a basal series of three or four followed by an intermediate group of nine, and this by two, more widely separated, at distal end of vein.

Head, seen from above, subpentagonal, its greatest length equal to its greatest width; sides constricted behind eyes; front margin produced, and subangulated in middle, its width almost completely occupied by the antennæ; eyes dark red-brown, of medium size, moderately granulated, pile scattered, long; posterior orbits depressed. with a row of short sparse hairs parallel to them; vertex scarcely elevated, gradually descending toward apex where it merges into the front; ocelli yellow, inner margins red; anterior ocellus on upper margin of front; lateral ocelli contiguous to upper orbits; ocellar bristles moderately long; small bristles between anterior ocellus and the eyes; occiput striate, provided with two weak bristles; front produced to base of antennæ thence receding toward clypeus, furnished with a row of four weak bristles just beneath antennæ and two similar bristles near clypeal margin. Antennæ seven-jointed, approximate, base plainly visible from above; joint 1 shortest and thickest, one-half the length of the second; joints 2-4 increase in length in the order named; joint 4 is nearly as long as joint 6, which is larger than any other joint; joint 5 is slightly longer than the second and more slender than any of the preceding; joints 6 and 7 are closely united and together pyriform in shape; the latter is nearly one-half the length of the former; the first joint is subrotund; the second, somewhat barrel-shaped; the third subfusiform; the fourth and the sixth elongate ovate; the fifth submoniliform; the seventh lanceolate, its base narrower than the apex of the sixth; bristles and sensorial spines of joint 4 placed nearer the middle than usual.

Prothorax subquadrate, scarcely broader than head; sides very slightly constricted at anterior border; posterior angles narrowly truncate, provided with two bristles; shorter bristles or hairs are scattered over a triangular area extending backward from the front margin, and a smaller area near the posterior angles; anterior angles provided with equally small, but heavier bristles; surface apparently smooth; mesoscutum broadly convex, nearly smooth, furnished with short inconspicuous bristles each side and two submedian bristles on disc. The scutellum, obtusely ridged, feebly sculptured, provided with two short, heavy, approximate bristles on ridge near basal margin.

Abdomen slender; apex abruptly conical, resembling that of females of this family; sides distinctly sculptured; segments with a few bristles or coarse hairs laterally and on apical border of their ventral surface; caudal segments with longer and stronger radiating bristles arranged in two rings as in females.

Legs slender; anterior femora scarcely expanded; posterior tibiæ spiny on inner margin and at apex; their tarsal joints with apical spines. Anterior wings lanceolate, humeral angle moderately arched; cubitus extending entire length of wing; radial vein obsolete at base and nearly obsolete at tip; costal spines, 22-24; cubital spines, 15-16, arranged in

groups, three or four at base, followed by a group of nine, and this by two more widely separated, placed at distal end; radial spines, 13; anal spines, 5; longitudinal vein of posterior wing distinct.

General color fuscous; third and fourth joints of antennæ entirely and sometimes base of fifth, legs, except more or less of dorsal surface, yellowish; thorax, especially the sutures, tinged with yellow-ferruginous; abdomen varying from fuscous to yellowish or pale fuscous; apex always dark; dorsal aspect of femora generally concolorous with head; anterior wings subfuliginous with a broad, indistinctly defined, pale sub-basal band; posterior wings subhyaline.

Described from eleven specimens taken at Ames, Iowa, on *Cyperus*, corn and in sweeping grass in August and November.

GENUS CHIROTHRIPS, HAL.

This genus is represented by a single species, *Chirothrips antennata*, Osb., which is of a brownish-black color with third joint of antennæ paler; second joint is quite characteristic, being trapezoidal with acute angle outward.

Chirothrips antennata, Osb.

Can. Ent. Vol., XV, p. 154. [1883.]

GENUS THRIPS.

- | | | |
|-----|---|---|
| A. | Head of medium size; eyes moderately prominent; antennal joints 3-5 elongate..... | 1 |
| AA. | Head small; eyes very prominent; antennal joints 3-5 not elongate..... | 8 |
| 1. | Antennæ eight-jointed..... | 2 |
| | Antennæ seven-jointed..... | 7 |
| 2. | Sixth joint of antennæ annulated..... | 3 |
| | Sixth joint of antennæ not annulated..... | 6 |
| 3. | Ocelli widely separated; long bristles at all angles of prothorax; spines present at apex of all tibiæ, numerous and heavy on wings, on radial vein 12-14..... | 4 |
| | Ocelli subapproximate; single bristle of medium length at each posterior angle of prothorax, none at anterior angles; spines present at apex of posterior tibiæ only, on radial vein 2..... | 5 |
| 4. | Size medium; head, from dorsal view, rectangular; antennæ approximate..... | (<i>Euthrips</i>) <i>tritici</i> Fitch. |
| | Size large; head from above pentagonal; antennæ subapproximate..... | (<i>Euthrips</i>) <i>maidis</i> n. sp. |
| 5. | Wings more or less distinctly clouded; brown markings on thorax and band at base of abdominal segments 2-7 distinct.... | <i>variabilis</i> , n. sp. |
| | Wings nearly uniformly fuliginous; brown markings distinct on thorax; abdomen immaculate..... | var. <i>a</i> . |
| | Wings and body, pale; markings, obsolete..... | var. <i>b</i> . |
| | Wings distinctly trifasciate; broad brown band on head | |

- and thorax respectively; abdominal segments 1-3 and 7-10 entirely brownvar. c.
6. Head, from dorsal view, semiovate; ocelli subapproximate, conspicuous; spines and bristles, short and few; bristles on penultimate segment of abdomen equally long *striata*, Osb. Head, from dorsal view, subrectangular; ocelli remote, inconspicuous; single strong bristle at each posterior angle of prothorax; intermediate bristles on penultimate segment of abdomen, one-half as long as lateral bristles, *inæqualis*, n. sp.
 7. Size medium; antennæ sub-approximate; ocelli inconspicuous; prothorax, transverse; bristles at posterior angles of medium length; spines at base of cubitus arranged in two groups *tabaci*, Lind. Size large; antennæ approximate; ocelli, conspicuous; prothorax, subquadrate; bristles at posterior angles of prothorax, long; spines at base of cubitus in single group .. *lactuæ* n. sp.
 8. Antennæ eight-jointed; ocelli approximate; spines and bristles, except those on abdomen, long and slender; bristle at middle of each lateral margin of prothorax, one at each anterior and two at each posterior angle *pallida*, n. sp.

Thrips (Euthrips) tritici, Fitch.

[Second report.] Trans. N. Y. State Agr. Soc. for 1855, p. 536; Osborn Can. Ent., Vol. XV, p. 156 (1883).

Thrips (Euthrips) maidis n. sp.

Female. Length, 1.83-2. mm. A large species slightly variable in color, brownish-black, but sometimes paler; annulus on antennæ, extremities of femora and tibiæ, lower surface of the latter and sutures of abdomen yellowish-white; thorax, especially its sutures, tinged with yellowish-ferruginous; anterior wings dusky white; head pentagonal, front margin produced and rounded in the middle; ocelli distant, antennæ subapproximate; spines and bristles strong, blackish, arranged much as in *E. tritici*, Fitch; costal spines 25-29; cubital, 19-23; radial, 15-16; anal, 5; internal, 1.

Head, from dorsal view, pentagonal, scarcely broader than long; its sides parallel; anterior border produced and rounded in the middle; occiput less than one-half the length of the head measured on a median line, plainly striated; genæ uniformly full; eyes rather large, coarsely granulated, feebly pilose; orbits yellow, encircled with a few short hairs; ocelli, pale yellow, margined with red crescents, widely separated and arranged in a broad triangle with its lateral angles contiguous to superior orbits; vertex broad, gently convex between lateral margins; produced cephalad and provided with a transverse row of four short hairs near its anterior margin; the front wide with medial, longitudinal elevation; antennal sockets occupying less than its entire width, making antennæ subapproximate, more widely separated than in *E. tritici*, Fitch; antennal joints 3 and 4, occasionally base of 5, white, the rest, black; joint 1 globose, more than one-half as long as joint 2; the latter subglobose, somewhat contracted toward base, both joints more robust than those following; joints 3-5 elongate, submoniliform, decreasing in size in the

order named; the third nearly as long as the sixth; apical joints subequal, minute; all joints thinly covered with microscopic hairs; bristles or stiff hairs on basal and intermediate joints which on distal joints are replaced by slender hairs; sensorial spines on the third, fourth and sixth joints, distinct; clypeal, subantennal and postocular bristles present, the last less conspicuous than in *tritici*; mouth parts distinctly asymmetrical; each joint of maxillary palpi cylindrical, narrower than the preceding; first and third subequal in length, and second shorter than either.

Prothorax about one and one-half times as broad and equally as long as preceding segment; anterior angles rectangular, posterior rounded, sides slightly converging cephalad; disc striate and sparsely hairy; front and hind borders more deeply striate or rugose, bristly; the most conspicuous bristles are arranged as follows: One long bristle at each anterior and two at each posterior angle; two shorter bristles on anterior margin, two on posterior margin and one on disc near each posterior angle.

Meso-metathorax, subquadrate; mesoscutum more finely striate than prothorax, with small bristles, one at each lateral angle, two near and two on posterior margin; scutellum as long as mesoscutum, narrow, not strongly carinate; base transversely striate, sides longitudinally rugose; basal bristles as in *tritici*.

Abdomen broad, ovate, basal segments and sides sculptured, bristles similar to those of *tritici*.

Legs, with numerous short bristles; all tibiae and joints of posterior tarsi with terminal spines; anterior femora incrassate, their tibiae stout.

Wings rather broad; humeral arch not prominent; surface minutely pilose; veins distinct, uniformly and heavily spinose; anterior and posterior basal cross veins present; cubitus inserted in marginal at tip of wing; radius obsolete at proximal end, but perceptible before it unites with the posterior basal cross vein; costal spines longer than those on the other veins, numbering from twenty-five to twenty-nine; cubital, from nineteen to twenty-three; radial, from fifteen to sixteen; anal, five, gradually increasing in size from one to five; internal, one; posterior wings hyaline; longitudinal vein indistinct, except at base.

This form approaches closely the dark colored specimens of *tritici*, from which it may be separated by its larger size, the annulus on the antennae, and especially by the shape of the head, which is pentagonal instead of rectangular, and the less approximate antennae.

Described from twenty-nine specimens taken at Ames, Iowa, in July, August, September and January.

Thrips variabilis n. sp.

Head transverse. Antennae eight-jointed, distant; ocelli approximate. Each posterior angle of prothorax provided with a single medium sized bristle; bristles on penultimate segment of abdomen not strongly radiating, not extending backward beyond the base of the succeeding row; radial vein bispinose, obsolete; legs slender.

Female. Length from .84-1.23 mm. Head one-half as long as broad; viewed from above, subrectangular; anterior margin straight; occiput short, transversely convex and striate; distinct oblique depression behind each eye; genae moderately full; vertex abruptly ascending, tumid

across whole anterior border; ocellar area small, elevated; ocelli approximate, inner margins heavy, conspicuous; ocellar bristles not more than one-half the length of the head; eyes large, prominent, feebly pilose. Antennæ eight-jointed, distant, moderately bristly; basal joint short, thick, hidden from dorsal view by vertex; the following joint longer, more robust, globose; joints 3-6 elongate; joint 3 the longest, subfusiform; joint 4 a little shorter than joint 3, elongate-modioliform; joint 5 obovate, intermediate in length between 2 and 4; the remaining joints sessile, together elongate-conical; joint 6 equal to joint 4 but a little stouter; joints 7 and 8 minute, together one-half as long as preceding, line of separation between them oblique; sensorial spines on joint 6 originate beyond middle; four short bristles in transverse row on front above antennæ, and one behind each eye; mouth parts nearly symmetrical.

Prothorax broader than long; anterior angles prominent, rectangular; posterior angles broadly rounded and furnished with a single bristle; surface plainly and uniformly marked with transverse striæ, with a few short slender bristles on front margin and more on disc. Mesoscutum is quite convex from base to apex, marked with fine transverse striæ, and provided with four short bristles on disc. Scutellum with triangular area at base striate as in mesoscutum, furnished with four basal bristles.

Abdomen broad, ovate; sides, under high power, appear thickly set with minute appressed hairs; a pair of bristles occurs on disc of each segment from the second to the seventh; they are approximate on the second and gradually become more widely separated on the succeeding segments; lateral bristles few and short; apical border at sides and on ventral surface of segments bordered with minute ciliæ interspersed with coarse hairs or bristles; caudal spines rather light; those on penultimate segment directed backward and extending only to base of following segment; terminal spines a little longer than the preceding, radiating at sides.

Legs very slender, somewhat bristly; tarsi elongate; anterior femora not dilated; apex of intermediate and posterior tibiæ and of posterior tarsal joints terminating in short spines; inner margin of posterior tibiæ feebly spinose.

Wings; veins heavy; in anterior pair radius and cross veins obsolete; costal spines number 22-30; cubital, 20-26, arranged in two series; radial, 2; anal, 4; one near base of anal cell; longitudinal vein of posterior wing very heavy for two-thirds of the length.

Male. Length, 78-86 mm. Resembles the female very closely. Differs in being of smaller size, in having from 23-25 costal spines, 20-21 cubital: the remaining spines on the wing as in female. The apex of the abdomen is more blunt; the anal segment is cleft on either side, the lateral lobes terminate in two spines; the middle lobe is prolonged considerably beyond the lateral lobes, making apex more pointed than apex of male of *T. tritici*. The spines on preanal segment are similar to those in female.

This species presents considerable variation in color. The extreme forms are quite distinct and might almost be considered separate species were it not that in addition to the similarity in structure there is the occurrence of a series of intergradient forms.

Var. *a*. Female: General color yellowish-white, meso-metathorax pale yellow, basal joints of antennæ concolorous with head, joint 3 and base of joint 4 dusky; the remainder of the antennæ and spot at distal end of tarsi, brownish-black; eyes dark red-brown; ocelli nearly colorless; inner margins red; anterior wings indistinctly clouded with fuliginous at base, distal portion clearer; brown markings as follows: A clearly defined saddle-shaped patch on posterior portion of prothorax, concave along its front border, nearly interrupted by a wedge-shaped incision extending forward from posterior border; anterior border of mesonotum; scutellum except median stripe; bands at base of abdominal segments two to seven, dilated at sides, and narrower and fainter along intervening space; patch on upper side of all the femora, darkest on posterior pair.

One specimen, taken on clover August 14, 1893, and one on hackberry, October 6, 1893, Ames, Iowa.

Another specimen taken on hackberry, October 6, 1893, at Ames, Iowa, corresponds with the description of variety *a* except that the thorax is a deeper yellow.

Another specimen taken on elm, August 21, 1894, is more uniformly yellow, the anterior wings more uniformly dusky, bands at base of abdominal segments narrower and other markings fainter.

A fourth specimen that may be placed in this group resembles the first, but it is of a deeper yellow color; the markings on the prothorax are prolonged farther backward, and the wings are more uniformly fuliginous. Ames, Iowa, Oct. 8, 1893.

Var. *b*. Male and female: Body pale yellowish, immaculate; apical joints of antennæ black, remainder pale; wings and fringes tinged with yellowish.

Hawthorn and hackberry, Ames, Iowa, October 6, 1893.

Var. *c*. Male and female: Wings nearly uniformly fuliginous; last three joints antennæ, distal half of joints 4 and 5 black, sometimes intermediate joints altogether dusky; brown markings very distinct, confined to two large spots on thorax and scutellum respectively, the latter oblong and approximating posteriorly; abdomen immaculate.

Hawthorn and hackberry, October 6, 1893, Ames, Iowa.

Var. *d*. Male and female: This variety is characterized by having the wings fuliginous, trifasciate with white bands, and in being more heavily marked with brown; the markings on the thorax and bands at base of first, second and third (sometimes of second and third only), and seventh and eighth segments of the abdomen are extended until they coalesce and form broad bands; the dorsal surface of the head is brown; sometimes all of the caudal segments are brown; the legs are white, with brown streaks on dorsal surface of femora, and frequently on tibiæ also; antennæ as in preceding variety.

On smartweed, June 16, 1893, and on cucumber, July 28, 1893, Ames, Iowa.

By the shape of the head and by the antennal characters this species is allied to *T. tritici*, but it may readily be distinguished from it by the smaller and more approximate ocelli, the absence of large conspicuous bristles on the thorax, the difference in the number of spines on the wing, and the more slender legs.

Thrips (Euthrips) striata, Osb.

Can. Ent., Vol. XV, p. 155.

Thrips inequalis, n. sp.

Female: Length, 88 mm.; yellow; style and distal portion of antennal joints, 3-6, black; joint 6 distinctly annulated toward apex; posterior angles of prothorax with a single bristle; lateral bristles on dorsum of penultimate segment of abdomen twice as long as intermediate pair.

Head, broader than long, contracted at posterior border, occiput forming not more than one-half of its dorsal surface; genæ uniformly full; eyes of medium size, moderately prominent, distinctly pilose; vertex uniformly tumid at anterior margin, becoming transversely convex and descending toward posterior margin; ocelli subapproximate; front, above insertion of antennæ, longitudinally elevated along median line.

Antennæ subapproximate; the two basal joints stout, subequal; the second barrel-shaped, more than one-half as long as succeeding; joints 3-6 subequal in length and less elongate than in *T. tritici*; joints 3 and 4, thick, irregularly turbinate, gibbous below insertion of sensorial spines; joint 5, smaller and more regular in shape; the remaining joints form an elongate oval; joint 6 has a distinct articulation on distal half, similar to the annulation on the sixth antennal joint of *T. striata*, Osb.; this may be an indistinct annulation, in which case the antennæ would be properly considered nine-jointed, three of the joints forming the style; the ultimate joint is nearly cylindrical and longer than the penultimate, which is of the same length as that portion of the joint 6 between the annulation and the apex; the joints are furnished with a few medium-sized bristles or stiff hairs, which become finer toward the distal end of the antennæ; sensorial spines as in *T. tritici*.

The prothorax is one and one-half times as long as the head, equally as broad at anterior border and about one-third broader at posterior border. The disc is convex, rather indistinctly striate and sparsely set with stiff, blackish hairs or bristles, which are almost entirely wanting on median portion, and most numerous near lateral and posterior borders. Posterior angles with a single long bristle.

The disc of the mesoscutum is convex, finely striate, elevated at posterior border, provided with a single short bristle near each lateral angle, two on disc and two on posterior margin. The scutellum is trapezoidal, gently sloping from the very small elevated area near base toward posterior and lateral margins; on the basal margin are two widely separated and two short approximate bristles.

The abdomen is ovate, resembling that of *T. tritici*, Fitch, in an arrangement of bristles, except that the median pair on penultimate segment is but one-half as long as those on either side.

Legs, especially femora and tibiae, thinly covered with short, coarse hairs which are replaced by bristles at apex of anterior and intermediate tarsal joints; inner margin of posterior tibiae feebly spinose; its apex and apex of its tarsal joints terminating in spines; anterior femora moderately dilated.

Anterior wings nearly attain tip of abdomen: veins heavy; inner marginal vein very distinct; costal fringe rather heavy; costal vein bears from 24-28 spines; radius, 18-19, those on basal half of vein separated into two groups of four each, the intervals between the rest growing wider toward the distal end of the vein; cubitus, 10-11; anal, 5; anal cell, 1.

Color yellow, deeply tinged with orange on thorax and abdomen, faintly dusky along median line of thorax and abdomen; head and two basal joints of antennae, whitish; proximal portion of joints 3-6, dusky; remainder of antennae and spot near apex of tarsi, black; eyes, red-brown; ocelli, pale yellow; inner margins, orange red; spines and bristles blackish; anterior wings and fringes tinged with dusky yellow.

Described from a single specimen taken with *T. tritici* on aster at Ames, Iowa, September 16, 1893.

Thrips tabaci, Lind.

Schädlichsten Insekten des Tabak in Bessar. Abien., pp. 62-63. (1888)

Thrips lactuce, n. sp.

Female: Length, 1.40 mm. General color pale yellow, with two broad diverging stripes on middle of thorax, a narrow band at base and one or more spots at sides of abdominal segments brown. Form elongate; anterior border of head convex. Antennae seven-jointed, proximal joints pale, remaining joints black. Wings variable in size. Ocelli conspicuous, placed close together near posterior margin of vertex. Spines and bristles stout, on thorax, arranged much as in *T. tritici*; the cubital spines are grouped into two series, a basal group of seven, followed by three, more widely separated, on distal portion of vein.

Head scarcely broader than long; outline seen from above semiovate; occiput, feebly striate, one-half the length of the head, with shallow, longitudinal furrow each side behind the eye; genae, broad, full, prolonged posteriorly; vertex elevated, convex between the eyes, ascending and expanding towards apex, front margin arcuate; ocelli conspicuous, remote from anterior border of vertex, inner margins heavy, contiguous in front; ocellar area elevated; ocellar bristles of medium size; eyes, moderate, pilose; a row of bristles on front, beneath insertion of antennae, is partially visible from above; a few microscopic bristles around orbits; antennal sockets prominent, easily seen from above; antennae approximate, seven-jointed; the intermediate joints elongate; joint 1 is one-half the length of joint 2, equal to or longer than joint 7, semiglobose; joints 2-5 are subequal in length; joint 2 is cupshaped, a little shorter but much stouter than any of the three immediately following; joints 3-5 are moniliform;

pedicel of 3 is short; joints 6 and 7 together form an elongate oval; the latter is acuminate at apex two-fifths the length of the former and terminates in two or three long slender hairs; surface of all the joints set with minute appressed hairs and furnished with a few bristles which are arranged in a preapical ring on joints 2-5, and on remaining segments are replaced by slender hairs; sensorial spines on joints 3, 4 and 6, distinct.

The prothorax is subquadrate, a little longer and wider than preceding segment; posterior angles nearly rectangular; posterior border margined; surface nearly smooth and, with the exception of two discal areas, covered with coarse, stiff hairs which are largest near lateral and posterior borders; two short bristles at each anterior angle and four longer ones near front border; two large, strong, subequal bristles at each posterior angle, two of moderate length on hind border, and a similar one on disc near each posterior angle.

The surface of the mesoscutum is apparently smooth, its posterior discal portion only moderately elevated, provided with two small bristles; two similar bristles occur on the posterior border, and one at each lateral angle. The metanotum is very short. The scutellum is obtusely carinated, its surface longitudinally striate, provided with two approximate submarginal bristles on anterior portion of disc, and two, more widely separated, on basal margin.

Abdomen is quite uniform in width, convex above, striate at base and at sides; base slender; apex short, conical; segments constricted, bearing a few stiff hairs on dorsal and ventral surfaces and a few bristles at sides; both hairs and bristles become stronger on anal segments, where the latter are arranged in two rings.

Legs, especially posterior pair, slender; anterior femora but slightly expanded; hind tibiae spiny on inner margin, terminating in three strong spines, joints of their tarsi also furnished with apical spines; entire surface bristly, especially at apex of intermediate and anterior tibiae.

Wings varying in size from rudimentary to fully developed; the anterior pair slightly dusky, posterior pair hyaline; in fully developed wing the cilia on costal border of each pair is short and sparse, on posterior border longer but not very heavy; venation of anterior wings rather weak; anterior and posterior basal cross veins present, but not distinct; costal vein furnished with 18-21 spines; cubitus, 10; radius, 10-11; anal, 5; anal cell, 1; spines on cubitus are arranged in a basal group of seven, followed by three more widely separated on distal end of vein; longitudinal vein of posterior wings incrassate at base, not quite attaining tip of wing.

Color usually pale yellow, deeper on thorax and legs, the latter frequently dusky; head and proximal joints of antennae white, intermediate joints brownish-black at base, the rest of the antennae deep black; occiput often tinged with yellow, sometimes dusky; eyes dark red-drown; ocelli yellow, inner margins brick-red; prothorax at margins, disc of mesonotum, pleurae, except upper portion of mesopleurae in front, narrow medium stripe on scutellum, pale; two spots or patches on prothorax, sometimes diffuse and coalescing sometimes nearly or quite obsolete, two broad, approximate stripes on scutellum, diverging slightly and extending outward and backward in a broken and interrupted line to lateral margin, upper portion of mesopleurae in front, brown; abdomen somewhat dusky, more or less pale

at sides and toward apex; narrow basal band on segments 2-7, expanding laterally and broken up into spots, one of which is more conspicuous than the others, brown.

Femora and tibiae dusky or brownish on upper surface, pale on lower surface and at base, the latter also pale at tip; anterior wings dusky yellowish; spines brown.

By its seven-jointed antennae. *T. lactucae* is allied to *T. tabaci*, Lind., but it is more heavily marked with brown; the color of the intermediate joints of the antennae is darker; the antennae and the ocelli more approximate; the ocelli more conspicuous and farther removed from the anterior margin of the vertex; the prothoracic bristles larger and less uniformly distributed, being entirely absent from two discal areas; those at posterior angles, longer; proximal spines on cubitus arranged in a single group.

Described from numerous specimens taken on wild lettuce in October, November and March, at Ames, Iowa.

T. lactucae bears some resemblance to *T. tritici* in size and general color, from which it may be easily separated by the fewer antennal joints, less rectangular head, less widely separated ocelli, absence of long bristles at anterior angles of prothorax, less numerous cubital spines and their arrangement in groups, absence of spines at apex of intermediate and anterior tibiae and inner margin of posterior tibiae.

From *T. striata* it may be known by the difference in number of antennal joints, absence of annulation on sixth joint, presence of longer and more numerous spines and bristles.

Thrips pallida n. sp.

Female: Length 1.12 mm. Color varying from white to pale yellow. Antennae, beyond basal joints, more or less dusky. Head small, eyes large. Anterior wings partially trifasciate. Bristles on anterior portion of body long and slender. Prothorax characterized by the presence of a long bristle on the middle of each lateral margin in addition to those at anterior and posterior angles.

Head small, about as long as broad. Occiput very short, not more than one-third the length of the head. Eyes dark red-brown, very large and prominent, sparsely and feebly pilose. Vertex narrow, elevated, transversely convex, ascending toward the anterior margin, the latter arcuate. Ocelli in middle of vertex, nearly colorless, their inner margins white, contiguous anteriorly. Ocellar bristles as long as the head. Front prominent, bearing a row of recurved bristles above insertion of antennae. Mouth parts short, nearly symmetrical.

Antennae approximate; the two basal joints the stoutest; joint 1 semi-globose, one-half the length of joint 2; the latter is stouter than the former, barrel-shaped, equal in length to joint 5, and a little shorter than joints 3 or 4; these are robust, subequal in length and broadly obovate, the pedicel of joint 3 is short and slender; joint 5 is oval and less robust than the two immediately preceding; the remaining joints are sessile, together form

an elongate oval; joint 6 is longer than any other joint; joints 7 and 8 are short and of equal length, base of former narrower than apex of 6; apex of 8 is lanceolate. Bristles and hairs are of equal size, and arranged much as in *T. tritici*. The long sensorial spine on outer side of joint 6 originates below the middle of the joint.

The prothorax is convex; its sides converge cephalad; its surface is nearly smooth, with a double median transverse groove or double impressed line and a few short and several long slender bristles, the latter arranged as follows: one at each anterior angle, two on intervening space of anterior border, one at middle of each side, one near and two at each posterior angle. The mesoscutum is longitudinally convex, its surface nearly smooth, furnished with two lateral bristles directed inward, and two smaller ones on disc and on posterior border, respectively. The scutellum is subrectangular, obtusely carinated, descending toward the apex; on basal margin provided with two distinct bristles which extend nearly to apex.

The abdomen is slender at base, ovate, with few conspicuous bristles; those at apex of ultimate segment much shorter and weaker than those on preceding segment.

Legs are moderately stout, bristly; anterior femora incrassate, their tibiae stout; spines present at apex of posterior tibial and tarsal joints, on inner margin of tibiae replaced by bristles.

The anterior wings are whitish, slender, rather thin, subfasciate with three dusky spots; the first near base of anal area, the other two dividing the remainder of the wing into three subequal parts; sometimes a faint spot may be detected near apex of wing; these spots are variable in distinctness and may be obsolete; ciliae of inner margin, light; of outer margin, sparse and scarcely longer than the spines with which they are interspersed. Radial-vein is obsolete between base of wing and posterior basal cross vein, consequently it appears to originate in the cubitus. Both radius and cubitus terminate abruptly before attaining marginal vein. Cross veins connecting costal and cubital veins are obsolete. The costal vein bears from 15-20 spines; the cubital, 10; radial, 5; anal, 4, and posterior marginal vein 1, placed opposite the posterior basal cross vein. The posterior wings are hyaline; proximal end of longitudinal vein incrassate.

Male. Length .97 mm. Smaller than the female, but very similar in distinctive characters. Apex of abdomen is bluntly conical, less truncate than in male of *T. tritici*, partially trilobate, the lateral lobes are very narrow, shorter than the middle lobe, and terminate in a single long bristle. Penultimate segment terminates in a row of short sparse bristles, on dorsum, and single long spine on each side.

Described from ten females and seven males. Taken on bean and elm at Ames, Iowa; on blackberry at Belle Plaine, Iowa, and on hop at Barraboo, Wis.

Thrips pallida is a well marked species and is readily separated from the other species included in this paper by the small head, the presence of a bristle on middle of lateral margin of prothorax, the feeble armature of inner margin of posterior tibiae and the number of spines on the front wings.

NOTE ON A NEW SPECIES OF PHLÆOTHIRIPS, WITH DESCRIPTION.

HERBERT OSBORN.

In connection with the paper by Miss Beach on the Thripidæ it seems desirable to describe a species which has for a long time been in our collections, but has not received a technical description.

Phlæothrips verbasci, n. sp. Black, polished; head quadrate with a prominent post-ocular bristle; prothorax widened behind; first joint of anterior tarsi armed on inner side with a curved tooth.

Female: Head quadrate, very slightly constricted behind, a prominent bristle behind the eye; antennæ light yellowish with dusky base and tip, joints 1 and 2 black, 3-6 yellow, 7-8 dusky, ending with two bristles; prothorax widening behind, with prominent angles, three lateral bristles; meso and meta-thorax subquadrate. Legs black except anterior tibiæ and all tarsi which are yellow, the tarsi somewhat clouded with dusky. Anterior tarsi with a short curved tooth on inner side of first joint at middle. Wings hyaline except base of anterior pair, which is fuliginous; anterior pair with no fringe at base; anal vein entire; median vein distinct at base, but becoming obsolete; three long spines in a row on the inner side of the median vein near base; posterior wings at base with two long, slender bristles near together on hind margin; abdomen at apex with six long and seven short bristles; tube reticulate.

Male smaller than female and having two slender spines on a slight elevation at side of the anterior margin of the first segment of the abdomen.

Length of male 1.50-1.60 mm., female 1.80-1.90 mm.

This species stands near to *nigra*, Osb., but differs decidedly from that species in the more quadrate head, prominent posterior angles of the prothorax, as also in the presence of two prominent bristles just behind the eyes and the different number and character of bristles at apex of tube.

It occurs almost invariably in mullein, hibernating in the stools, and may be found in early spring at the base of the fresh leaves, especially among the dense interior leaves. The whitish, cylindrical eggs are deposited during April, and larvæ develop on the mullein leaves. The larvæ differ decidedly from the larvæ of *nigra*, in being yellow or orange instead of deep red.

Adults, bred forms of which matured June 20th to 26th, are found in mullein blossoms in midsummer (July), and probably produce a second brood. Adults have been taken in September in the seed pods, and in November at the base of dead mullein stalks.

This is the species referred to in my article on "The Food Habits of the Thripidæ" (Insect Life, Vol. I, p. 141) as *Phlæothrips* sp., the species being cited in evidence of an herbivorous diet for the Thripidæ.

INDEX.

- Address, annual, of president, 17.
 Anatomical studies of the leaves of
 Sporobolus and Panicum, 148.
 Anatomy of Sphaerium, 173.
 Andrews, L. W., on reduction of sulphuric
 acid, 37.
 Annual address of president, 17.
 Articles of incorporation, 8.
 Area of slate near Nashua, N. H., 66.
 Associate members, list of, 11.
- Bacteria**, Chromogenic, 135.
 Bain, H. F., report of librarian, 14.
 Ball, E. D., a study of the genus *Clastop-
 tera*, 182.
Baris confinis, 207.
Baris dolosa, 210.
 Beach, Alice M., contributions to a
 knowledge of the thripidae of Iowa,
 214.
 Biologic notes on certain Iowa insects, 202.
 Boston basin, geology of, 72.
 Buchanan gravels: An interglacial de-
 posit in Buchanan county, Iowa, 58.
- Calvin**, S., the Le Claire limestone, 52.
 Buchanan gravels, 58.
 Carver, G. W. and Pammel, L. H., fungus
 diseases, 140.
 Carver, G. W., and Stewart, F. C., inocula-
 tion experiments with *Gymnosporan-
 gium macrospus*.
 Cephalopods, two remarkable, from upper
 Paleozoic, 76.
Cercopidae, 182.
Chironomus, sp., 211.
 Chromogenic bacteria, some notes on, 135.
Cicadidae of Iowa, observations on the, 195.
Cicada dorsata, 193.
 septem-decim, 194.
 tillicen, 193.
 Clastoptera, a study of the genus, 182.
Clastoptera, 183.
Clastoptera delicata, 184.
 obtusa, 188.
 proteus, 186.
 canthocephala, 188.
 Clays of the Indianola Brick, Tile and
 Pottery works, 40.
 Combs, Robt., and Pammel, L. H.,
 Chromogenic bacteria, 135.
 Cone-in-Cone, nature of, 75.
 Constitution of the academy, 7.
 Corresponding members, list of, 11.
 County parks, 91.
 Cyclostome ear, homologies of, 29.
 Cosmos weevil, 207.
- Deep Wells** in Des Moines county, some
 facts brought to light by, 62.
 Drew, G. A., Anatomy of *Sphaerium sulca-
 tum*, 173.
- Ear of cyclostome, homologies of, 29.
 Encrinurus, variation in the position of
 the nodes in axial segments of pygi-
 dium of a species of, 79.
 Entomostraca, preliminary notes on the
 Iowa, 170.
Epicærus imbricatus, 205.
- Flora** of Western Iowa, 106.
 Fellows, list of, 10.
 Ferns, comparative study of spores of
 North American, 159.
 Flora of Western Iowa, 106.
 Forest distribution in Iowa, 96.
 Forest preservation, resolutions on, 15.
 Frisk, E. E., and T. P. Hall, mad stone, 45.
 Fultz, F. M., Recent discoveries of glacial
 scorings, 60.
 Some facts brought to light by deep
 wells, 62.
 Fungus diseases of plants at Ames,
 Iowa, 1895, 140.
- Geology** of the Boston basin, 72.
Gelechia sp., 202.
 Glacial scorings, recent discoveries of, in
 S. E. Iowa, 60.
 Grasses, anatomical study of, 150.
 Gravitation, physical theories of, 47.
 Ground cherry seed moth, 202.
Gymnosporangium macrospus Inoculation
 experiments with, 162.
- Hall**, T. P., physical theories of gravita-
 tion, 47.
 Unit systems and dimensions, 45.
 Hall, T. P. and Frisk, E. E., a mad stone, 45.
Heliothrips, 216.
 Homologies of the Cyclostome ear, 29.
 Hendrixson, report of library commit-
 tee, 15.
- Inoculation** experiments with *Gymnos-
 porangium macrospus*, 162.
 Insects, biologic notes on certain Iowa, 202.
- Keyes**, C. R., note on the nature of cone-
 in-cone, 75.
 Two remarkable Cephalopods from the
 Upper Paleozoic, 76.
- Lake** preservation, resolution on, 15.
 Lead and Zinc mines, 64.
 Le Claire, limestone, 52.
 Leonard, A. G., recent developments in
 the Dubuque lead and zinc mines, 64.
 Librarian, report of, 14.
 Loess, a theory of the, 82.
- Mad** stone, a, 45.
 Macbride, T. H., county parks, 91.
 Forest distribution in Iowa, 96.
 The nomenclature question among
 the slime moulds, 101.

- Melampsalta parvula*, 202.
 Members, associate, 11.
 Corresponding, 11.
 Membership of the Academy, 10.
 Metazoa, sex in, 35.
 Myxomycetes, 101.
- Nautilus ponderosus*, 76.
 Needed changes in scientific methods, 17.
 Nomenclature question among the slime moulds, 101.
 Norris, H. W., address by, 17.
 Homologies of Cyclostome ear, 29.
 Norton, W. H., variation in the position of the nodes on the axial segments of Pygidium of a species of Encrinurus, 79.
 Nutting, C. C., origin and significance of sex, 32.
- Officers of the Academy, 5.
 Origin and significance of sex, 32.
Orthoceras fanslerensis, 77.
 Osborn, H., Observations on the Cicadidae of Iowa, 195.
 Note on a new species of Phloeothrips with description, 228.
 Report of secretary-treasurer, 13.
 Osborn, H. and Mally, C. W., biologic notes on certain Iowa insects, 202.
- Pammel, Emma, and Serrine, Emma, some anatomical studies of the leaves of Sporobolus and Panicum, 148.
 Pammel, L. H., notes on flora of western Iowa, 106.
 Pammel, L. H., and Carver, G. W., fungus diseases of plants at Ames, Iowa, 1895, 140.
 Pammel, L. H., and Combs, Robt., some notes on Chromogenic bacteria, 135.
 Panicum and Sporobolus, anatomical studies of the leaves of, 148.
 Panicum, 155.
 Panicum, capillare, 156.
 crus-galli, 157.
 proliferum, 156.
 Parks, county, 91.
 Phloeothrips, note on a new species of, with description, 228.
Phloeothrips verbasci n. sp., 228.
 Physical theories of gravitation, 47.
 President's annual address, 17.
 Proceedings of tenth annual session, 13.
- Recent developments in the Dubuque lead and zinc mines, 64.
 Recent discoveries of glacial scorings in southeast Iowa, 68.
 Reduction of sulphuric acid by copper, as a function of the temperature, 37.
- Report of librarian, 14.
 Report of secretary-treasurer, 13.
 Resolutions on preservation of forests and lakes, 15.
 Ross, L. S., Preliminary notes on the Iowa Entomotrachea, 170.
- Secretary-treasurer, report of, 13.
Salix amygdaloides, perfect flowers of, 89.
Sericothrips? 216.
Sericothrips? *perplexa*, 216.
 Sex, origin and significance of, 32.
 Shimek, B., A theory of the Loess, 82.
 Perfect flowers in *salix amygdaloides* Ands, 89.
 Serrine, Emma, and Pammel, Emma, Some anatomical studies of sporobolus and Panicum, 148.
 Slate near Nashua, N. H., Area of, 66.
 Slime-moulds, Nomenclature question among, 101.
Sphaerium sulcatum, Anatomy of, 173.
 Spores of North American ferns, study of, 159.
 Sporobolus and panicum, anatomical studies of the leaves of, 148.
 Sporobolus, 151.
 Sporobolus cryptandrus, 153.
 heterolepis, 151.
 hookeri, 153.
 vaginæflorus, 155.
 Stewart, F. C., and Carver, G. W., Inoculation experiments with *Gymnosporangium macropus*, 162.
 Sulphuric acid, reduction of, 37.
- Thripidae of Iowa, contributions to a knowledge of, 214.
Thrips inaequalis, 223.
 laticca, 224.
 maidis, 219.
 pallida, 226.
 variabilis, 220.
Tibicen rimosa, 200.
 Tilton, J. L., area of slate near Nashua, N. H., 66.
 Notes on the geology of the Boston basin, 72.
- Unit systems and dimensions, 45.
- Weaver, C. B., comparative study of the spores of North American ferns, 159.
- Youtz, L. A., clays of the Indianola Brick, Tile and Pottery works, 40.
- Zinc mines, recent developments in lead and, 64.

PROCEEDINGS
OF THE
IOWA ACADEMY OF SCIENCES
FOR 1896.

VOLUME IV.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

DES MOINES, IOWA:
F. R. CONAWAY, STATE PRINTER.
1897.

PROCEEDINGS

OF THE

IOWA ACADEMY OF SCIENCES

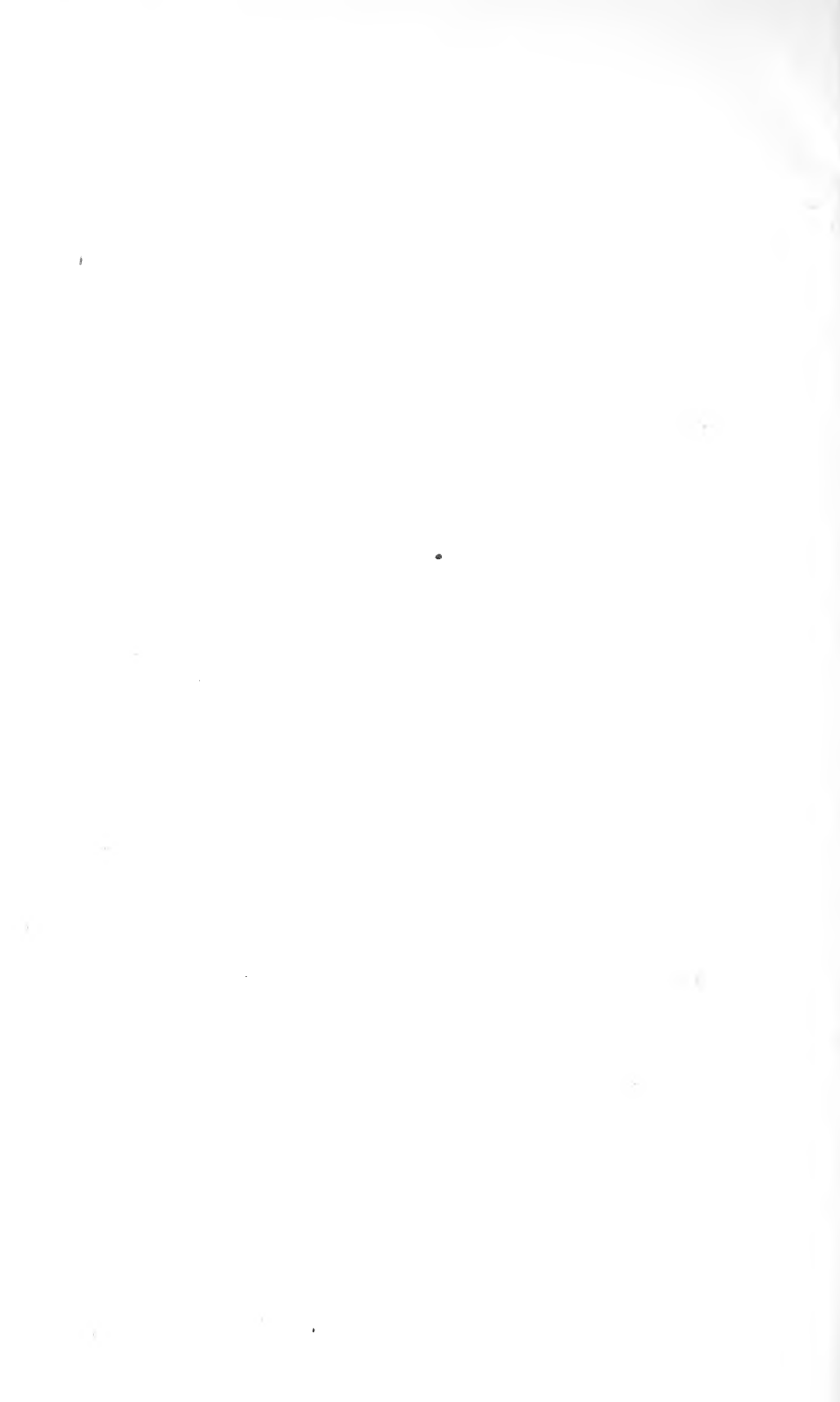
FOR 1896.

VOLUME IV.

EDITED BY THE SECRETARY.

PUBLISHED BY THE STATE.

DES MOINES:
F. R. CONAWAY, STATE PRINTER.
1897.



LETTER OF TRANSMITTAL.

21.8.99

AGRICULTURAL COLLEGE, }
AMES, Iowa, January 28, 1897. }

To His Excellency, FRANCIS M. DRAKE, Governor of Iowa:

SIR—In accordance with the provisions of chapter 86, laws of the Twenty-fifth General Assembly, I have the honor to transmit herewith the proceedings of the eleventh annual session of the Iowa Academy of Sciences.

With great respect, your obedient servant,

HERBERT OSBORN,

Secretary Iowa Academy of Sciences.

188089

OFFICERS OF THE ACADEMY.

1896.

President.—T. PROCTOR HALL.

First Vice-President.—W. S. FRANKLIN.

Second Vice-President.—T. H. MACBRIDE.

Secretary-Treasurer.—HERBERT OSBORN.

Librarian.—H. FOSTER BAIN.

EXECUTIVE COMMITTEE.

Ex-Officio.—T. PROCTOR HALL, W. S. FRANKLIN, T. H. MACBRIDE, HERBERT OSBORN.

Elective.—W. S. HENDRIXSON, M. F. AREY, W. H. NORTON.

1897.

President.—W. S. FRANKLIN.

First Vice-President.—T. H. MACBRIDE.

Second Vice-President.—B. FINK.

Secretary-Treasurer.—HERBERT OSBORN.

Librarian.—H. FOSTER BAIN.

EXECUTIVE COMMITTEE.

Ex-Officio.—W. S. FRANKLIN, T. H. MACBRIDE, B. FINK, HERBERT OSBORN.

Elective.—L. S. ROSS, J. L. TILTON, C. O. BATES.

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ALMY, F. F.	Iowa College, Grinnell
ANDREWS, L. W.	State University, Iowa City
AREY, M. F.	State Normal School, Cedar Falls
BAIN, H. F.	Geological Survey, Des Moines
BALL, E. D.	Agricultural College, Ames
BARRIS, W. H.	Griswold College, Davenport
BATES, C. O.	Coe College, Cedar Rapids
BEACH, ALICE M.	Decorah
BENNETT, A. A.	Agricultural College, Ames
BEYER, S. W.	Agricultural College, Ames
BISSELL, G. W.	Agricultural College, Ames
CALVIN, S.	State University, Iowa City
CHAPPEL, GEORGE M.	Signal Service, Des Moines
COMBS, ROBERT.	Agricultural College, Ames
CONRAD, A. H.	Parsons College, Fairfield
CRATTY, R. I.	Armstrong
CURTISS, C. F.	Agricultural College, Ames
DAVIS, FLOYD.	Des Moines
DREW, GILMAN.	Newton
ENDE, C. L.	Iowa City
FINK, B.	Upper Iowa University, Fayette
FITZPATRICK, T. J.	Lamoni
FRANKLIN, W. S.	Agricultural College, Ames
FULTZ, F. M.	Burlington
GOSSARD, H. A.	Ames
HALL, T. P.	Minturn, Colorado
HANSEN, N. E.	Brookings, South Dakota
HAZEN, E. H.	Des Moines
HENDRIXSON, W. S.	Iowa College, Grinnell
HEILEMAN, W. H.	Pullman, Washington
HOLWAY, E. W. D.	Decorah
HOUSER, G. L.	State University, Iowa City
JACKSON, J. A.	Des Moines
KELLY, H. V.	Mount Vernon
LEONARD, A. G.	Des Moines
LEVERETT, FRANK.	Denmark

MALLY, C. W.	Wooster, Ohio
MARSTON, A.	Agricultural College, Ames
MACBRIDE, T. H.	State University, Iowa City
NEWTON, G. W.	Cedar Falls
NILES, W. B.	Agricultural College, Ames
NORRIS, H. W.	Iowa College, Grinnell
NORTON, W. H.	Cornell College, Mount Vernon
NUTTING, C. C.	State University, Iowa City
OSBORN, HERBERT	Agricultural College, Ames
PAGE, A. C.	State Normal School, Cedar Falls
PAMMEL, EMMA	Des Moines
PAMMEL, L. H.	Agricultural College, Ames
REPPERT, F.	Muscatine
RICKER, MAURICE	Burlington
ROSS, L. S.	Drake University, Des Moines
SAGE, J. R.	State Weather and Crop Service, Des Moines
SCHAEFFER, C. A.	State University, Iowa City
SCHLABACH, CARL	High School, Clinton
SHIMEK, B.	State University, Iowa City
STANTON, E. W.	Agricultural College, Ames
STOKEY, STEPHEN W.	Coe College, Cedar Rapids
TILTON, J. L.	Simpson College, Indianola
VEBLEN, A. A.	State University, Iowa City
WALKER, PERCY H.	State University, Iowa City
WEEMS, J. B.	Agricultural College, Ames
WINDLE, WILLIAM S.	Penn College, Oskaloosa
WITTER, F. M.	Muscatine
YOUTZ, L. A.	Simpson College, Indianola

ASSOCIATE MEMBERS.

BALL, C. R.	Agricultural College, Ames
BARTSCH, PAUL	Burlington
BEARDSHEAR, W. M.	Agricultural College, Ames
BLAKESLEE, T. M.	Des Moines
BROWN, EUGENE	Mason City
CARTER, CHARLES	Fairfield
CARVER, G. W.	Tuskegee, Alabama
GIFFORD, E. H.	Oskaloosa
JOHNSON, F. W.	Grinnell
MILLER, G. P.	Des Moines
MILLS, J. S.	Eugene, Oregon
OSBORN, B. F.	Rippey
OWENS, ELIZA	Bozeman, Montana
REED, C. D.	Ames
RODWELL, W. W.	Marshalltown
ROLFS, J. A.	Le Claire
SCHULTE, J. I.	Agricultural College, Ames
SIRRINE, EMMA	Dysart
WEAVER, C. B.	Ames

CORRESPONDING MEMBERS.

ARTHUR, J. C.	Lafayette, Indiana
BARBOUR, E. H.	State University, Lincoln, Nebraska
BEACH, S. A.	Geneva, New York
BESSEY, C. E.	State University, Lincoln, Nebraska
BRUNER, H. L.	Irvington, Indiana
CALL, R. E.	Louisville, Kentucky
COLTON, G. H.	Virginia City, Montana
CROZIER, A. A.	Ann Arbor, Michigan
GILLETTE, C. P.	Agricultural College, Ft. Collins, Colorado
HALSTED, B. D.	New Brunswick, New Jersey
HAWORTH, ERASMUS.	State University, Lawrence, Kansas
HITCHCOCK, A. S.	Agricultural College, Manhattan, Kansas
JAMESON, C. D.	
KEYES, C. R.	State Geologist, Jefferson City, Missouri
LONSDALE, E. H.	Missouri Geological Survey, Jefferson City, Missouri
MALLY, F. W.	Hulen, Texas
MCGEE, W. J.	Bureau Ethnology, Washington, D. C.
MEEK, S. E.	State University, Fayetteville, Arkansas
PARKER, H. W.	New York City, New York
PATRICK, G. E.	Department Agriculture, Washington, D. C.
ROLFS, P. H.	Lake City, Florida
SIRRINE, F. ATWOOD.	Jamaica, New York
SPENCER, A. C.	Johns Hopkins University, Baltimore, Maryland
STEWART, F. C.	Jamaica, New York
TODD, J. E.	State University, Vermillion, South Dakota
WINSLOW, ARTHUR	Kansas City, Missouri

PROCEEDINGS
OF THE
ELEVENTH ANNUAL SESSION
OF THE
Iowa Academy of Sciences.

The eleventh annual session of the Iowa Academy of Sciences was held in committee room No. 1 of the capitol building in Des Moines, December 29 and 30, 1896. In business sessions the following matters of general interest were acted upon.

REPORT OF THE SECRETARY-TREASURER.

MEMBERS OF THE ACADEMY—The past year has been one of substantial progress for the Academy. We have added five fellows and seven associate members. Our proceedings were duly printed and form a volume of 230 pages.

It is my sad duty to chronicle the death of one of our most honored members, Dr. Chas. Wachsmuth, of Burlington, who died very soon after our last meeting. I would suggest that a committee be appointed to draft suitable resolutions to be published in our forthcoming volume of proceedings and to include, if possible, a sketch of his life.

FINANCIAL STATEMENT.

Accounts and vouchers submitted herewith show receipts of \$151.69 and expenditures of \$79.72, leaving a balance charged to the treasurer of \$71.97.

SUMMARY OF RECEIPTS AND EXPENDITURES.

RECEIPTS.

Balance from last year	\$ 55.99
Membership fees.....	37 00
Annual dues from members	55.00
Proceedings sold	4.70
Total	\$151.69

EXPENDITURES.

Stamps and stamped envelopes	\$ 4.84
Printing programs, notices, receipts, etc.....	11.00
Reprints of author's extras.....	32.00
Express and postage on proceedings.....	21.91
Miscellaneous items of expense.....	9 97
Total	\$ 79.72

The committee on treasurer's accounts reported as follows:

To the Iowa Academy of Sciences: Your committee appointed to examine the accounts of the treasurer find the same to be correct.

(Signed) G. E. FINCH,
A. A. VEBLEN,
A. G. LEONARD,
Committee.

Resolutions urgently opposing the pending bill in congress for the restriction of experiments on living animals were passed, also one in support of the movement for a director of scientific bureaus in the department of agriculture.

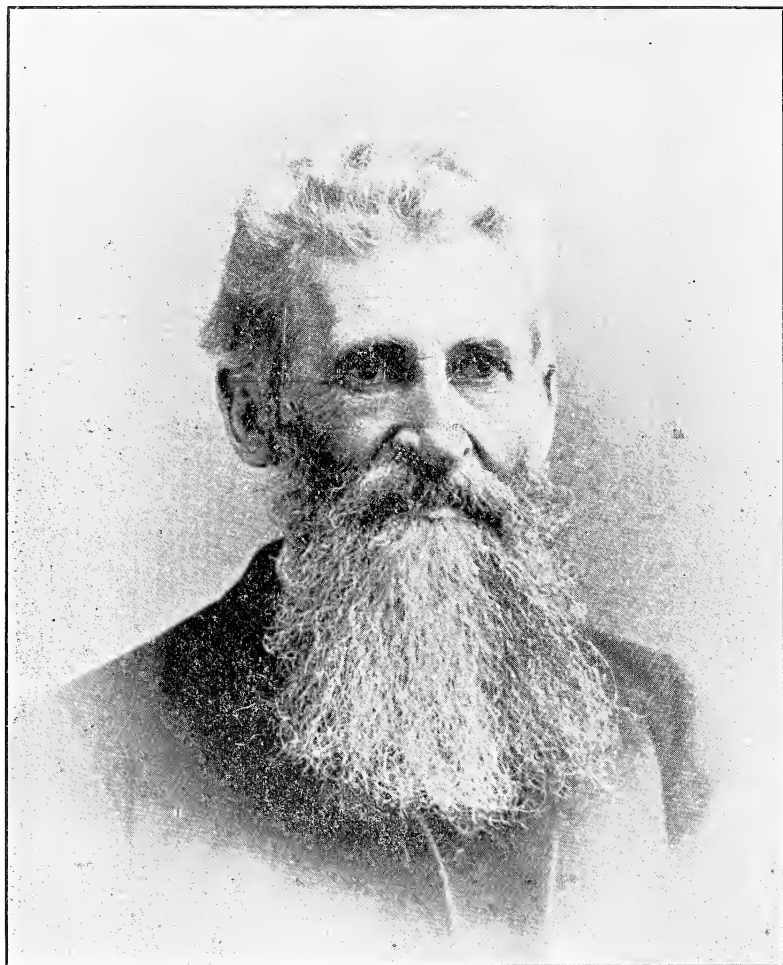
A subscription was voted for the Pasteur monument fund.

In addition to the appended papers, read in full or by title and which were by vote of the council referred to the secretary for publication, the following subjects were presented:

Mr. Charles Carter, of Fairfield, remarked upon the Iowa Odonata, calling attention to what had been done in the way of study of our native species and requesting the members to assist him by sending specimens of such species as they could with a view to the preparation of a catalogue of the species of the state.

Prof. A. H. Conrad, of Fairfield, read some preliminary notes on the Ophidia of Iowa, indicating the extent to which the species of the state are known, the probability of the rapid extermination of many of the species and the desirability of a prompt study of our native fauna. He requests material and correspondence.

Professor Conrad exhibited an archæological specimen recently unearthed near Fairfield: a small box hollowed from



Yours very truly
Charles W. Schmitt

two pieces of wood evidently hermetically sealed and which contained sheets of birch bark bearing aboriginal hieroglyphs.

The committee appointed to prepare a memorial in honor of Dr. Charles Wachsmuth and consisting of Prof. Samuel Calvin and Dr. Charles R. Keyes, presented the following sketch, prepared by the long time friend and former co-laborer of Dr. Wachsmuth, Dr. Charles R. Keyes. The plate for the portrait was kindly loaned by Mr. Charles Aldrich, of the historical department.

MEMORIAL OF CHARLES WACHSMUTH.

Since our last annual gathering the Academy has lost one of its most illustrious and honored members, the state one of its most distinguished citizens and American science one of its most indefatigable workers. By the death of Charles Wachsmuth an epoch in the history of Iowa science closes. To those of you who were intimately acquainted with our departed friend and associate no words that we can utter will seem extravagant. Yet it appears befitting at this time, especially for the consideration of those of you who were not so fortunate as to come in frequent contact with him, to give some estimate of his personality and worth.

Charles Wachsmuth was born September 13, 1829, in the city of Hannover, Germany. He was the only son of a lawyer of considerable reputation who was a member, in 1848, of the German parliament of Frankfurt. From early childhood he was always in feeble health. It was the wish of his father that he should study law, and he was accordingly sent at an early age to the high school of his native place to receive a classical education; but to his father's great grief and his own, he was obliged, at the age of sixteen, to give up all studies on account of failing health, and on the advice of the attending physician to enter a mercantile career.

In 1852 the young Hannoverian came to America, having been sent to New York as an agent of a Hamburg shipping house, in which capacity he served for a period of over two years. Severe illness compelled him to leave the sea coast, and upon the advice of friends he settled in Burlington. In 1855 Mr. Wachsmuth was married, and in the same year embarked on his own account. The dry, western country did not bring about the expected improvement in health, and his physician advised that as much time as possible should be spent in the open air, suggesting that the collecting of fossils, which abounded in the rocks of the neighborhood, would soon provide an incentive for sufficient exercise. It did not take long for him to develop into an enthusiastic collector, so that days at a time were spent in quarries and ravines around the city, his wife often looking after the store. The new mode of life at once produced a wonderful improvement of health. In the course of a few years a fine collection of crinoids had been brought together. It reached such dimensions that it attracted

the attention of eastern scientists. Prof. Louis Agassiz came to see it on his lecturing trip to the west, and Meek and Worthen asked the loan of specimens for description in the geological reports of Illinois, which were then being prepared.

In 1865 Mr. Wachsmuth closed out his business and, accompanied by his wife, made a trip to Europe. On his way he visited Cambridge, upon invitation of Professor Agassiz, and saw the large collections in the Museum of Comparative Zoology. Until then he had seen very few crinoids aside from those found at Burlington. His delight knew no bounds as he studied in Cambridge the fossil crinoids from other localities, and a number of specimens of living types. In Europe all sorts of invertebrate fossils were collected and visits made to the principal museums. When England was reached it was a great surprise to find that the reputation of the Burlington collection had already preceded him.

On returning to Burlington, after an absence of almost a year, Mr. Wachsmuth resolved to devote the rest of his life to scientific pursuits, and to direct his whole attention to crinoids. Living far from scientific centers, and not having access to literature, he had to depend for study largely upon his own specimens. This, however, proved afterwards an advantage, rather than a drawback, for independent thought and original research.

It was in 1873 that Professor Agassiz, on his return from the Pacific coast, paid a second visit to Burlington. He was greatly surprised at the enormous growth of the collection since he had last seen it, and, struck by the beauty and perfection of the specimens, he intimated that he was anxious to procure the collection for Cambridge, at the same time expressing a desire to have Mr. Wachsmuth go with it and take charge of all the crinoids in the museum. The negotiations were soon completed, and a few months later Mr. Wachsmuth was installed in the Museum of Comparative Zoology as an assistant. It was Professor Agassiz who induced the new assistant to publish the results of his observations under his own name, on the ground that he was doing a great injustice to himself by placing them in the hands of others. The position, which was held until the death of Professor Agassiz, gave ample opportunity for Mr. Wachsmuth to become fully acquainted with the literature on the crinoids, and it was here that the foundation of the later great work was laid.

After the death of Agassiz a second trip to Europe and a visit to the Orient, was made. On returning in 1874 Mr. Wachsmuth had not a single specimen in his possession. However, it took only a few years to make up another collection that was larger and much superior to the first. A year or two later he made the acquaintance of Mr. Frank Springer, then a young lawyer of Burlington, and an enthusiastic student of the natural sciences; a warm friendship soon sprung up between them. They studied together, and from 1878 the results of their researches were published under joint authorship. In the following years the collections increased rapidly by extensive purchases. From a trip to Europe Mr. Springer brought home a fine selection of Dudley crinoids, embracing nearly all of the species of that locality, and a large assortment of the Carboniferous species of England and Ireland. Among his acquisitions were also rare forms from Belgium, a majority of the Eifel species, fine specimens from Russia and Bohemia, and a large amount of material from the Mesozoic and later formations. The collection was enlarged further by extensive

exchanges with collectors in this country and Europe, and by having collectors in the field. Liberal purchases for the library were made, and when work was commenced on the monograph, nearly the whole crinoidal literature, from the time of J. S. Miller to date, was at hand. By examining the titles of their publications it will be noticed that Wachsmuth and Springer took very little pride in describing new species, their attention being directed mainly to the morphology, with a view to classification, and to the revision of the work of the earlier writers. As the work of the monograph was nearing completion, Prof. Alexander Agassiz, the present director of the Museum of Comparative Zoology, offered to publish it, in the best style possible, as one of the memoirs of the museum, and in this series it now appears, a model of typographic art.

Mr. Wachsmuth was at one time vice-president of this society. He was also a fellow of the American Association for the Advancement of Science, of the Geological Society of America, and of the Davenport Academy of Sciences. He was a corresponding member of the Philadelphia Academy of Natural Sciences, and a member of the Imperial Society of Natural Sciences, of Moscow, Russia. For many years he carried on an extensive and intimate correspondence with leading scientists of this country and Europe. That which passed between Dr. P. Herbert Carpenter, the most eminent European authority on Echinoderms, and Mr. Wachsmuth during the past ten years would alone fill a large volume.

For many years Mr. Wachsmuth was in delicate health and was obliged to spend the winter seasons in the South. The early spring was usually passed in the mountains of Alabama, Tennessee and Kentucky, where immense collections of both crinoids and blastoids were brought together. On all of these trips he was accompanied by his faithful wife, who is, herself an excellent and indefatigable collector.

The sudden demise of our associate took place on February 7, 1896.

Although rarely able to be present at the meetings of our Academy no member took greater interest in its deliberations nor had greater solicitude for its welfare and progress.

From early childhood Mr. Wachsmuth possessed a frail constitution which continually threatened to give away, yet he withstood the inroads of an organic disease long enough to nearly complete the allotted span of human life, of three score years and ten. During the last three years his health gradually failed, until for several months previous to the end, herculean efforts were necessary to enable him to work even for a short time each day. His last illness covered only a few days, and even the iron will, which had so often before overcome a long-standing ailment, finally had to give up to the physically weak heart. To within a day of his demise, with a zeal that is begotten only for love of the sublime, he continued to apply himself to the finishing stages of the crowning glory of his life—the Monograph of the Fossil Crinoids. The first half only was written and the final proofs of this part were barely read when the angel of death beckoned him. The triumphant joy of beholding the completed structure of a noble life's work was not his lot. Deprivation of what he held dearest took the place of conquering satisfaction, in the very hour of victory.

Few outside of the little circle of workers directly interested in the rather limited field of investigation can appreciate the great importance and originality of Mr. Wachsmuth's work. Compared with the extent of

the great field of science itself the results may seem small; measured by the standard of individual achievement the outcome is stupendous. In the special department of knowledge which he represented no one person has done more to raise it to the high place that it now occupies.

Wachsmuth belonged to that illustrious school of naturalists which Louis Agassiz founded in this country. His main efforts were entirely along the lines of inquiry pointed out by the Swiss savant. It was the establishment, upon a morphological basis, of a rational classification of a group of organisms. The group chosen was the crinoids, or sea lilies, a class of animals which is now all but extinct, but which in ages past was one of the most abundant forms of life. Most of the material was fossil and the difficulties surrounding the investigation were such as to students of living animals would be insurmountable. Although the work was far from finished at the time of his demise the main and most important features of the scheme were fully established and the Wachsmuth classification of crinoids has been adopted the world over.

In the Monograph of the Fossil Crinoids, which is a huge quarto of 800 pages in two parts and an atlas of eighty plates, is contained the mature reflections of thirty years' continuous thought and reflection. Twenty years ago, when at Cambridge with Agassiz, the foundations of his life's work were laid. In a little paper "On the Internal and External Structures of Paleozoic Crinoids," published in 1877, was stated the essential propositions on which rested all subsequent work. The ancient crinoids were divided into three primary groups, the separation being based chiefly upon the structure of the tegmen.

The effects of Wachsmuth's work has been completely to revolutionize the ideas which prevailed concerning the crinoids and to place the whole systematic arrangement of the groups upon an enduring basis. The stages in the development of those changes are easily traced in the various publications which were issued from time to time and culminated in the monumental monograph.

THE STATE QUARRY LIMESTONE.

BY SAMUEL CALVIN.

At the state quarries, or North Bend quarries, in sections 5 and 8 of Penn township, Johnson county, Iowa, there is a body of limestone of Devonian age, possessing marked characteristics which set it off sharply from the rest of the Devonian in the upper Mississippi valley. The formation has a thickness of about forty feet. At present there is some uncertainty as to its exact taxonomic relations.

On fresh fracture the state quarry rock is light gray in color. In texture it varies somewhat in different beds, but

near the middle of the formation it is composed of coarse, imperfectly comminuted fragments of brachiopod shells cemented together, the spaces being filled with interstitial calcite. Among the recognizable species of shells *Atrypa reticularis* is the most common, but some beds contain very large numbers of *Terebratula* (*Crancena*) *iowensis*. At some horizons shells of an *Orthothetes* are common. *Orthis impressa* is not rare, and *Rynchonella pugnus* (*Pugnax pugnus*) occurs occasionally. The shells, or fragments of shells, making up the limestone are not embedded in a matrix. They are simply piled on each other and cemented together in a manner illustrated by the formation of the modern coquina along the east coast of Florida. The rocks near the middle of the state quarry beds are a brachiopod coquina having the interstices completely filled with crystalline calcite.

Near the middle of the formation the rock consists of thick ledges which, some years ago, were worked extensively. From these beds came the large limestone blocks used in the foundation of the new state capitol. Although the ledges show no definite lamination, and split as readily in one direction as another, the weathered surfaces on opposite sides of the numerous joints often show obscure signs of oblique bedding. The material was evidently swept into place by moderately strong currents.

The ledges worked in connection with the building of the new capitol are the heaviest afforded by the formation. The lowest one is four feet in thickness. It is made up of rather finely triturated brachiopod shells, the most common species being *Atrypa reticularis*. This bed, it seems, did not furnish satisfactory material for it was quarried only to a limited extent. The ledge furnishing the greater number of available blocks lies directly above the first. It is five feet in thickness, and is intersected by numerous joints. Among the great multitude of unrecognizable fragments of which it is chiefly composed it contains large numbers of entire detached valves of *Atrypa* and *Orthothetes*. The next ledge in ascending order to furnish usable stone is separated from the last by a talus-covered space of two or three feet. It also is five feet thick, and in it *Atrypa* and *Terebratula* are the prevailing brachiopods. In a fourth ledge, four feet in thickness, the rock is fine grained, the materials are very perfectly comminuted, species cannot be recognized, but it is evident that the bed is composed of debris from brachiopod shells mingled with triturated fragments of crinoids. Above the fourth ledge the layers vary

from six inches to two feet in thickness, and toward the upper part of the exposure the rock is made up almost wholly of the remains of crinoids.

Below the first ledge noted above the beds vary from a few inches to a foot or more in thickness, the thinner beds prevailing near the base of the formation. Brachiopod shells constitute the major part of the material of which they are composed.

Among the waste material of the main quarry there are many large blocks, eighteen inches thick, through which masses of chert are irregularly distributed. The position of the bed from which the chert-bearing blocks were obtained was not determined, though it is probable that it lies in the talus-covered space between ledges two and three of the main workable portion of the quarry. Whatever its position, it is a bed of remarkable interest, for it is in places crowded with fish teeth that lie embedded in the chert or among triturated brachiopod shells in the calcareous portions of the layer. It looks as if an entire fish fauna had suffered death at once. Such general fatality may have been produced by any one of several probable causes; and, furthermore, the cause was doubtless in some way related to the crustal movements recorded in the region, and to be noted further on. Changes in oceanic currents attended by rapid elevation or depression of temperature, earthquake shocks even, or concentration of sea water in an isolated basin, would be competent to produce the observed result. Whatever the cause, it was effective, and every square yard of sea bottom received its quota of dead fishes.

Several genera and species are indicated amid the profusion of fish remains interred in this old cemetery. One of the most common forms is the well known Devonian type, *Ptyctodus*. Teeth of this genus are sometimes literally crowded together to form a sort of fish tooth conglomerate. These teeth, or tritors, vary in size and shape and in the degree of wear to which they were subjected before the death of their owners; but in the opinion of experts to whom they have been submitted, they probably all belong to the single species, *Ptyctodus calceolus*. Along with *Ptyctodus* are remains of one or more species of Devonian Placoderms, as indicated by great numbers of imperfect dermal plates. The Dipnoan genus, *Dipterus*, is represented by a number of the interesting wing shaped teeth characteristic of this very old but persistent type; and there are

teeth evidently related to *Dipterus*, but so different as probably to make generic separation necessary.

But more interesting than all the rest, and far outnumbering the teeth that could at first sight be referred to *Dipterus* or to related genera, is a vast assemblage of teeth of varying shapes and dimensions, that bear a striking external resemblance to the crushing teeth of certain genera of sharks. In the opinion of Dr. C. R. Eastman, however, it is doubtful if there are any Selachian teeth in the entire lot. He finds that, microscopically, they all, so far as sections have been made, are identical in structure with the teeth of Lung fishes, or Dipnoans. They seem, indeed, to be primitive Dipnoans exhibiting a stage of evolution not far removed from the point whence the Dipnoan and Elasmobranch types diverged; and their careful study will doubtless throw much light on the nature of the relationships existing between these two groups of fishes. Dipterine fishes have long been known from the Devonian of eastern Europe, but it is only recently that this type has been found in the Devonian of America. Until the discovery of the State quarry fish bed, our Devonian Dipterines all belonged to a single genus and came from the upper Devonian formations of Pennsylvania. Now we find the type in the Mississippi valley, and here it is represented by several genera, and is connected by intergradations with exceedingly primitive Dipnoan forms. The material has been placed in the hands of Dr. Eastman, whose full report on the subject will be awaited with much interest.

Distribution.—At present the state quarry limestone is known only in Johnson county, Iowa, though it doubtless occurs at other points in Iowa and adjacent states. The main body occurs in sections 5 and 8 of Penn township (T. 80 N., R. 6 W.). It is found in the bluffs on the west side of the Iowa river from the north line of section 5 to a little more than one-fourth of a mile below the north line of section 8, the principal development occurring near the south side of the first named section. The width of the area occupied by the formation in this region is less than half a mile. In fact in following up the small tributary valleys the state quarry stone is in most cases found to disappear in less than one-fourth of a mile.

A second body of state quarry limestone is found near the southwest corner of section 20, of Graham township, at which point the formation is almost exclusively crinoidal as to composition; a third body of this limestone, but of no great thickness,

is seen near the top of the hill southeast of the bridge over Turkey creek in section 23, Newport township; and another body of the same stone occurs in rather puzzling relations to the Megistocrinus beds in section 23, Big Grove township, southwest of Solon. At the last named locality Rynchonella, or Pugnax, is the prevailing fossil. The very fossiliferous limestone seen near the base of the quarry south of Shueyville is of a very different character and belongs to a different horizon.*

Taxonomic Relations.—As already intimated, the taxonomic relations of the state quarry stone are not very clear. At first it seemed that it might possibly represent local deposits made contemporaneously with the Cedar valley beds, but later investigations indicate that it is younger than the Cedar valley and was laid down on a deeply eroded surface. In support of this view it may be noted that at the mouth of the ravine below the south quarries in section 5 of Penn township, the state quarry stone rests on the Megistocrinus beds of the Cedar valley stage. In following up the ravine the quarry stone rises higher and higher in the bluffs and soon disappears, while the members of the normal Cedar valley section appear successively in the bottom of the creek. The contact of the two formations cannot, however, be definitely traced. On Rapid creek, in section 20 of Graham township, the relations are nearly the same. The state quarry stone occurs only a short distance above the Megistocrinus beds. At Solon the equivalent of the quarry stone occurs on the west side of a small ravine, while on the east side of the ravine, only four or five rods distant, the typical Megistocrinus beds, wholly different in character and with an entirely different fauna, occur at the same level. The quarry beds at the last named locality are composed largely of shells of Pugnax (Rynchonella). They extend westward along the north side of the valley of a small creek for about one-eighth of a mile and then suddenly disappear, their place in the low bluff being taken by the normal Megistocrinus beds of the Cedar valley section.

In the bluffs above the bridge over Turkey creek, at the point already noted, in section 23 of Newport township, these beds occur above the white limestone at the top of the Cedar valley formation. No Devonian beds of any kind have so far been

*McGee: Tenth Census Rept. Vol. X, Quarries and Building Stone, p. 262.

found above the state quarry stone. The anomalous relations of this formation, the limited areas to which it is confined, the abrupt manner in which it appears and disappears, sometimes at the level of one member of the Cedar valley section and sometimes at the level of another, all lead to the conclusion that it was deposited uncomformably on the Cedar valley limestone after the lapse of a considerable erosion interval. The same view is even more strongly suggested by the fact that in certain respects the fauna of the state quarry beds is unique. The deposit near Solon furnishes *Pugnax pugnus* Martin, *Melocrinus calvini* Wachsmuth, and a very peculiar Stromatoporoid, none of which are found in the other Devonian formations. Of other species that have a greater vertical range, as for example *Atrypa reticularis*, there is sufficient variation to distinguish them from individuals of the same species found at other horizons. The *Orthothetes*, so common in the beds in section 5 of Penn township, is associated with *Pugnax*, and like it is limited to the state quarry stage. The great mass of cemented crinoidal debris composing the beds in Graham township and the upper ten or fifteen feet of the formation at the state quarries has no parallel in any other stage of the Iowa Devonian. The presence of *Dipterus*, which elsewhere occurs only in the Upper Devonian, is likewise indicative of an interval between this stage and the Cedar valley beds below. In this connection it may be noted that the affinities of *Pugnax pugnus* is with the Carboniferous rather than the Devonian. These facts, coupled with the evidence of unconformity, would seem to place the formation near the closing stage of the Upper Devonian system, while the faunas of the Cedar valley stage correlate it with the Middle Devonian. The known phenomena concerning the state quarry limestone and its interesting fauna evidently require for their interpretation a number of crustal movements and a long period of erosion in the Iowa Devonian heretofore unsuspected.

STAGES OF THE DES MOINES, OR CHIEF COAL-BEARING SERIES OF KANSAS AND SOUTHWEST MISSOURI AND THEIR EQUIVALENTS IN IOWA.

BY CHARLES R. KEYES.

The principal coal-bearing formation of Iowa and other parts of the western interior basin is the lower coal measures, or Des Moines series as it is now termed. Although the formation has been long recognized in practically its present geologic limits it has been only very recently that any attempt has been made to even suggest subdivisions of the series. It is to these minor distinctive parts that have been made out clearly in southwest Missouri and the adjoining portions of Kansas that attention is directed.

Over the whole of its areal extent in the western interior coal field the Des Moines series, or productive coal measures, is clearly limited above by the Bethany limestone and below by the Mississippian limestones, or earlier formations. Until very recently no attempt has been made to subdivide the principal coal-bearing series of the region. Minor divisions have been vaguely recognized, however, in different parts of the area occupied by these rocks. In the southwestern extension of the belt the most definite information in regard to the detailed relations of the various strata has been obtained. In that part of western Missouri south of the Missouri river three stages have been traced out. They are known to extend northeastward into other parts of the state. Since these have been determined very similar lines have been recognized in Kansas, where special names have been applied.* The three stages that are capable of more or less clear demarkation in Missouri and Kansas are the Cherokee shales, at the bottom, the Henrietta limestones, and the Pleasanton shales at the top.

Cherokee Shales.—The term Cherokee as a designation for the lower part of the coal measures was first applied by Haworth

*Univ. Geol. Sur., Kansas, vol. I, p. 150, 1896.

and Kirk.* While it was not formally nor properly defined as a formation name subsequent description† leaves practically no doubt as to its extension. The name had been previously used by Jenney for the lead-bearing formations of the Mississippian series of southwest Missouri but only incidentally, and before it was proposed formally to use the title‡ thus, the term had been appropriated in another sense. Moreover, Cherokee, as applied to the lead-bearing rocks, covers an indefinite sequence of beds for which specific titles that are not well defined have been already adopted, so that even if the term in this sense had been formally suggested it could scarcely be considered as having priority. In this sense also the term has nowhere been accepted as a geological name, while it has been practically refused recognition by all who have had occasion to refer to it, either directly or indirectly.

The Cherokee contains a number of minor formations to which special names are applicable locally. These require no definition. They refer more directly to the coal seams, and thick sandstones.

Henrietta Limestone.—The name Henrietta was used by Marbut§ for a subdivision of the coal measures which gives rise, in southwestern Missouri, to a prominent physiographic feature called the Henrietta escarpment. It consists of several limestone beds of great persistency separated by shales, but presenting a sharp contrast to the underlying and overlying formations which consist of shales and sandstones.

In southeastern Kansas it embraces of Swallows sections|| essentially numbers 203 to 217, or from the top of the Pawnee limestone down to the cement rock under the Fort Scott limestone. In the more recent references¶ to these beds the same limestones are recognized but the lower bed is termed the Oswego limestone.

The Henrietta formation, in southwestern Missouri and southeastern Kansas at least, is a three-fold division, having an upper and a lower limestone separated by shale thirty to fifty feet thick and carrying thin beds of limestone.

To the lower or calcareous number the term Fort Scott limestone is properly applied. This is the name used by Swallow,

*Kansas Univ. Quart., vol. II, p. 105, 1894.

†Univ. Geol. Sur., Kansas, vol. I, p. 150, 1896.

‡Trans. American Inst. Min. Eng., vol. XXII, p. 171, 1894.

§Missouri Geol. Sur., vol. X, p. 44, 1896.

||Kansas Geol. Sur., Prel. Rep., pp. 24-25, 1866

¶University Geol. Sur., Kansas, vol. I, p. 151, 1896.

whose meaning can be easily defined. More recently another title has been given to practically the same formation, but as the two are essentially coterminous it seems that the earlier of the two can be retained with advantage. The latter term includes only a few layers additional, which are also well exposed at the typical locality. The latter term is Oswego, which, though used previously without definition, was described only very recently.*

The medial shale member may be designated as the Marmaton formation from the stream of the same name in Vernon county, Missouri, and Bourbon county, Kansas, where the shale may be considered as typically developed.

The Pawnee limestone forms the upper member of the Henrietta. The term was first used by Swallow† for a heavily bedded limestone occurring in southeastern Kansas.

Pleasanton Shales.—The name Pleasanton was first applied by Haworth.‡ There is, however, some difficulty in determining just what title is the proper one to use in this connection. Swallow§ seems to have had essentially the same idea in applying to the principal coal-bearing shales immediately overlying the Pawnee limestones in southeastern Kansas, the term “Marais des Cygnes coal series.” He, however, appears to have gotten the upper part considerably mixed, especially the limestones, if later work is to be relied upon. Only the lower half of this coal series can be regarded as forming the equivalent of the Pleasanton, or numbers 194 to 202 of Swallow’s section. These beds are typically exposed in Bourbon county, and along the Marais des Cygnes river in Linn county, Kansas, the locality being practically the same as that in which the town of Pleasanton is situated, so that the original localities for both are essentially the same. The “series,” however, evidently embraces so much more than it should to form a compact, easily defined formation, and the upper part, moreover, is so far from being correct that it would seem best not to attempt to restrict and redefine the limits of the formation in order to retain the name.

For the strata lying between the Pawnee and Bethany limestones Haworth and Kirk|| first suggested the name Laneville

*Univ. Geol. Sur., Kansas, vol. I, p. 151, 1896.

†Kansas Geol. Sur., Prelim. Rep., p. 24, 1866.

‡Kansas Univ. Quart., vol. III, p. 274, 1895.

§Kansas Geol. Sur., Prelim. Rep., pp. 22-24, 1866.

|| Kansas Univ. Quart., vol. II, p. 108, 1894.

shales. Had this term been defined in any way it would probably have to be adopted as the designation of the formation. Subsequently Haworth* without the slightest reference to this title, and without a very much better definition for the new name changed it to Pleasanton shales. As in a later publication† the latter term has been more clearly limited and applied, it should probably be regarded as the proper designation of the formation.

In Iowa there are recognizable in the Des Moines series (1) an upper shale bed of considerable thickness, which lies beneath the Bethany or Winterset limestone, (2) a lower shale bed, 300 to 400 feet thick which rests on the Mississippian and older strata, and (3), between the two, a set of beds that includes limestone layers which, though comparatively thin, rarely more than four to six feet, are of relatively great lateral persistency and carry at least one seam of workable coal. In southern Iowa the last mentioned beds appear to be best developed in Appanoose county and the adjoining districts. The Mystic coal, the seam having the greatest areal extent of any in the state, is included in this median member. The limestone beds are closely associated with the coal. The strata have a total thickness of perhaps seventy-five feet. They indicate an epoch, during which temporarily, marine conditions prevailed to a greater extent than during any other time between the secession of Mississippian deposition in the region and the introduction of the Missourian.

The exact relation between these particular subdivision lines of the strata of Iowa and of southwest Missouri have, of course, not been directly traced in detail, but the close resemblance of the vertical sections is so striking and the probabilities of their being equivalent are so great that it seems worth the while, at this time, to call attention to the facts, while the top and bottom of the Des Moines series, as a whole, has been clearly made out over the entire region.

*Kansas Univ. Quart., vol. III, p. 274, 1895

†Univ. Geol. Sur., Kansas, vol. I, p. 153, 1896.

VERTICAL RANGE OF FOSSILS AT LOUISIANA.

BY CHARLES R. KEYES AND R. R. ROWLEY.

Owing to peculiar phases in the erosion of the Mississippi river in northeast Missouri the basal portion of the Lower Carboniferous rocks is exposed to better advantage than perhaps anywhere else in the whole interior basin. In Pike county, Missouri, and in the contiguous parts of Illinois, not only does the lower part of the Carboniferous crop out along the streams, but vertical sections from the Hudson shales up to the Upper Burlington are obtainable in single exposures. In this locality the bluffs are high and the outcrops of the rocks under consideration are practically continuous along the great river for a distance of more than seventy-five miles.

The section at Louisiana, which may be regarded as typical, is given below, essentially as when first published several years ago,* except that for the present purpose, smaller zones are recognized.

SECTION OF ROCKS EXPOSED AT LOUISIANA, MISSOURI.

TERRANES.	Number	FORMATIONS.	Feet.
Pleistocene.	21	Soil, and red residuary clay, with abundant chert fragments	4
Upper Burlington limestone.	20	Limestone, brown, rather thinly bedded and cherty..	28
	19	Limestone, compact, thin-bedded, encrinital, with much gray chert in bands and nodules.....	18
	18	Limestone, yellowish-brown, rather soft, encrinital...	4
Lower Burlington limestone.	17	Limestone, bluish, fine-grained, siliceous.....	4
	16	Limestone, massive, white, encrinital, coarse-grained (upper white ledge).....	12
	15	Limestone, brown, encrinital, with irregular chert bands and nodules, and occasional thin clay partings	20
	14	Limestone, white, very heavily bedded, encrinital, some white chert (lower white ledge)	9
	13	Limestone, brown, encrinital, heavily bedded.....	6
Chouteau(?) limestone.	12	Limestone, yellow, massive, or heavily bedded, rather soft, fine-grained.....	9
Hannibal shales.	11	Shale, brown, very sandy, passing into soft sandstone locally.....	12
	10	Shale, green, sandy above.....	60

*Am. Jour. Sci., (3) vol. XLIV, p. 443, 1892.

SECTION OF ROCKS EXPOSED AT LOUISIANA—CONTINUED.

TERRANES.	Number.	FORMATIONS.	Feet.
Louisiana limestone.	9	Limestone, buff to gray, compact, very fine-grained, in layers four to six inches thick, similar to lithographic stone in texture.....	34
	8	Limestone, similar to above.....	8
	7	Limestone, similar to above, layers thicker and separated by buff sandy partings.....	6
	6	Shale, buff, sandy, two to six inches.....	½
Western Hamilton.	5	Shale, green or dark blue.....	2
	4	Shale, black, fissile.....	4
Niagara?	3	Limestone, magnesian, buff, massive.....	2
	2	Oolite, white, massive.....	8
Hudson.	1	Shale, blue, with thin bands of limestone, near Louisiana.....	40

The basal member of the section is the Hudson shale. When fully exposed in the neighborhood it attains a thickness of about seventy feet. It rests on a heavy magnesian limestone carrying characteristic Trenton fossils.

The next two higher members, Nos. 2 and 3, are provisionally referred to the Niagara. The oolite appears to be somewhat of a local phase, but is present not only in the vicinity of the town but all the way to Paynesville, a distance of eighteen miles. The formation appears to be represented elsewhere in the vicinity by fossiliferous limestones which are not oolitic. The organic remains contained are rather abundant. The buff massive layer is very thin at Louisiana, being only two feet in thickness in the river bluff in front of the town. Two miles southward, at the mouth of Buffalo creek, it increases to nine feet, and still further southward, on both sides of the Mississippi river, and southwestward toward Bowling Green, it attains a measurement of twenty-five to thirty feet in a distance of fifteen to twenty miles. It is almost destitute of fossils.

The next two, Nos. 4 and 5, belong to the Devonian. The lower black shale contains a characteristic fish fauna.

Numbers 6 to 9 form the Louisiana division of the Kinderhook. It is the lithographic limestone of the older state reports. For a long time the lithographic limestone has been regarded as the basal member of the Lower Carboniferous in the Mississippi valley. Recently* some doubt has been thrown upon the interpretation of the age of the formation. Regarding this question the following statements were made:

*American Geologist, vol. X, pp. 380-384, 1892; also Missouri Geol. Sur., vol. IV, pp. 54-55, 1894.

Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarksville principally, were the leading localities for a large proportion of the "Kinderhook" fossils originally described by Shumard, Hall, White, and Winchell. Most of these forms have a very decided Devonian aspect which gives a peculiar and characteristic physiognomy to the faunas of the three beds. Heretofore little mention has been made concerning the exact horizon of the fossils in question, mere reference to the "Lithographic" limestone, or Kinderhook beds, being considered sufficient. Later, however, extensive collections of fossils have been made at all three places just mentioned, as well as many intervening and neighboring exposures. Everywhere the Lithographic, or Louisiana limestone has been found to be essentially devoid of organic remains, except an occasional form in the thin sandy partings above the bottommost layer, which is less than one foot in thickness. At the very base of the limestone is a thin seam of buff, sandy shale, seldom over three or four inches in thickness. This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Spirifera hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of the western Hamilton.

Lithologically, the thin sandy layer is more closely related to the underlying shales than with the overlying limestone. Faunally, it has very much nearer affinities with the western Hamilton (Devonian) than with the Kinderhook (Lower Carboniferous). In Iowa the "Devonian aspect" of the Kinderhook faunas has disappeared largely, since Calvin's recent discovery that the "Chemung" sandstones of Pine creek, in Muscatine county, Iowa, are in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the Carboniferous is lost from view, almost completely, by eliminating the species found in the thin sandy seam at the base of the Louisiana or lithographic limestone. The faunas of the Devonian and Carboniferous of the upper Mississippi valley thus become more sharply contrasted than ever. The apparent mingling of faunas from the two geological sections, manifestly was based upon erroneous assumptions rather than upon the detailed field evidence.

Depriving the "Lithographic" limestone, almost entirely of the extensive fauna commonly ascribed to it, and which, as has been seen, comes from a thin seam lying below the calcareous layers its geological age becomes a problem yet to be solved. The few fossils known from the limestone itself have been heretofore rarely met with. It is not at all unlikely that the lower limestone of the Kinderhook eventually may prove to be of Devonian age. But until abundant evidence to this effect is found, it seems advisable to still consider the Louisiana (Lithographic) limestone as the basal member of the Carboniferous.

Since these remarks were made the organic remains which were found only in the thin basal shale (No. 6) have been obtained from higher levels, as is clearly brought out in the accompanying table. The whole formation is thus more closely related to the strata below than those above.

The Hannibal shales (Nos. 10 and 11) are almost wholly devoid of fossils in Missouri, but farther north, at Burlington,

where the beds have always been regarded as non-fossiliferous, an extensive fauna has been lately disclosed.* Its facies is very decidedly Devonian.

The thin, soft, earthy limestone (No. 12), which is nine feet in thickness at Louisiana, is believed to be the attenuated portion of the Chouteau limestone, though it is so closely associated with the lower beds of the Burlington, that it might be termed the Chouteau-Burlington. Toward the southwest the undoubted Chouteau limestone, before leaving Pike county, has a thickness of thirty feet, and still farther in the same direction in central Missouri the thickness increases to over 100 feet.

The lower Burlington limestone is separated upon lithological and faunal grounds into five zones, and the upper Burlington, as represented in the section, into three zones.

Nearly all of the strata are highly fossiliferous. The vertical section and the exposures are so extensive for a single locality that the facilities for determining the exact range of the various faunas stand unrivalled in the whole region. Moreover, a key to the stratigraphy of the entire province is furnished. Owing to unusually favorable opportunities for forming extensive collections of the fossils which are representative of the different horizons, the results are very complete. The determination of the faunal zones and their most important relationships as bearing upon the stratigraphy of the region are therefore of great interest. The subjoined tabular arrangement displays the more salient features in the distribution of the faunas.

TABLE SHOWING VERTICAL RANGE OF FOSSILS.

SPECIES.	Hudson.		Niagara.		Hamilton.		Louisiana.			Hannibal.		Chouteau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
PLANTS:																				
Plumulina gracilis (Shumard).....	x	..	..	..	..	..	..	..	..	..	..	..	..
Taonurus crassus? (Hall)	x	..	..	..	..	..	..	..	..	..
SPONGES:																				
Stromatopora sp?.....	..	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Palæacis enormis (Meek & Worthen)	x	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..
Conopterium effusum, Winchell.....	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..
CORALS:																				
Amplexus blairi, Miller.....	x	x	..	..	..	..	..
Amplexus sp?.....	x	x	x	x	..	..	..

*Iowa Geol. Sur., vol. III, p. 80, 1893.

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.		Niagara.		Hamilton.		Louisiana.			Hannibal.		Chouteau.		Lower Burlington.				Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>Amplexus fragilis</i> , White & St. John.	x	x	x	x
<i>Aulopora gracilis</i> , Keyes	x	x	x	x
<i>Chetetes</i> sp?	x	x	x
<i>Cyathophyllum</i> sp?	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Cyathophyllum</i> sp?	..	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Cyathophyllum</i> sp?	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Favosites</i> sp?	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Favosites favosa</i> ? (Goldfuss)	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Favosites forbesi</i> , Edw. & Haine.	..	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Halsites catenulatus</i> (Linnaeus)	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Cleistopora typa</i> ? (Winchell)	x	..	..	..	..	..	..	..	..
<i>Michelinia</i> sp?	x	..	..	..	..	x	..	..
<i>Monticulipora</i> sp?	..	x	..	..	..	..	..	..	..	..	..	..	x	x	..	..	..	..	..	..
<i>Monticulipora</i> sp?	..	x	..	..	..	..	..	..	..	..	..	..	x	..	..	..	..	..	..	..
<i>Monticulipora</i> sp?	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Monticulipora lycoperdon</i> ? (Say)	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Stenopora</i> sp?	x	..	..
<i>Streptelasma</i> sp?	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Striatopora carbonaria</i> , White	x	x	..	..
<i>Syringopora</i> sp?	x	..	..	..	..	..
<i>Zaphrentis acuta</i> , White & Whitfield	x	x	x	x	..	..	..	..	..	..	..	..	..	..	..
<i>Zaphrentis calceola</i> , White & Whitfield	x	x	x	x	x	x	x	x	x
<i>Zaphrentis centralis</i> , Edw. & Haine	x	x	x	x	x	x
<i>Zaphrentis elliptica</i> , White	x	x	x	x	x	..	..	..
<i>Zaphrentis</i> sp?	x	x	..	..	..	..	..	..	..
<i>Zaphrentis tantilla</i> , Miller	x	x	x	..	..	..	..
<i>Zaphrentis</i> sp?	x	..	..	..	..	..	..	..	..
<i>Zaphrentis</i> sp?	x	x	x	..	..	..	..
<i>Zaphrentis</i> sp?	x	x	x	..	..	..
<i>Zaphrentis</i> sp?	x	..	..
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?
<i>Zaphrentis</i> sp?						

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.		Niagara		Hamilton.		Louisiana.		Hannibal.		Chouteau.		Lower Burlington.				Upper Burlington.				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Barycrinus rhombiferus (Owen & Shumard)	x	x
Batocrinus æqualis (Hall)	x	.	.	.	.	.	.	.
Batocrinus æquibrachiatus (McChesney)	x	x	.
Batocrinus calvini, Rowley	x	.	.	.	.	.	.	.	.	.
Batocrinus christyi (Shumard)	x	x	.
Batocrinus clypeatus (Hall)	x	x	.	.	.	.	.	.
Batocrinus discoideus (Hall)	x	x	.	.	.	.	.	.
Batocrinus lepidus (Hall)	x	x	.	.	.	.	.	.
Batocrinus longirostris (Hall)	x	x	x	x	.	.	.	.	.	.
Batocrinus quasillus, Meek & Worthen	x	x	x	.	.	.	.	.	.
Batocrinus subæqualis (Hall)	x	.	.	.	.	.	.	.
Batocrinus turbinatus (Hall)	x	x	.	.	.	.	.	.	.	.
Batocrinus inflatus, Rowley
Batocrinus rotadentatus, Rowley	x	x	.	.	.	.	.	.
Batocrinus pyriformis (Shumard)	x	x	.	.
Batocrinus sp?	x	x	.	.	.	.	.	.
Batocrinus sp?
Eretmocrinus carica (Hall)	x	x	.	.	.	.
Eretmocrinus calyculoides (Hall)	x	.
Eretmocrinus coronatus (Hall)	x	x	.	.	.	.	.	.
Eretmocrinus konincki (Shumard)	x	x	.
Eretmocrinus leucostia (Hall)	x	x	.	.	.	.	.	.
Eretmocrinus verneuillanus (Shumard)	x
Eretmocrinus sp?	x	.	.	.	.	.
Eretmocrinus sp?	x	.	.	.	.	.	.	.
Eretmocrinus sp?	x	.	.	.	.
Eretmocrinus sp?	x	x	x	x	.	.	.	.	.	.
Eretmocrinus corbulis (Hall)	x	.	.	.	.	.	.	.	.
Eretmocrinus sp?	x	x	.	.
Eretmocrinus sp?	x	.	.	.
Belemnocrinus sp?	x	.	.	.	.
Calceocrinus ventricosus (Hall)	x	x	x	.	.	.	.	.
Catillicrinus wachsmuthi, (Meek & Worthen)	x	.
Codaster kentuckiensis, Shumard	x
Codaster gracillimus, Rowley	x	x	.	.	.	.	.
Codaster grandis, Rowley	x	.	.
Codaster sp?	x	x	.	.	.	.	.	.	.
Orophocrinus stelliformis (Shumard)
Orophocrinus inopinatus, Rowley	x	x	x	.	.	.	.	.	.
Cyathocrinus sp?	x	x	.
Cyathocrinus sp?	x
Cyathocrinus iowensis (Owen & Shumard)	x	x	.	.	.
Cyathocrinus sp?	x	.	.	.	.	.
Cyathocrinus sp?
Dichocrinus lineatus Meek & Worthen	x	x
Dichocrinus pisum, Meek & Worthen	x	x
Dichocrinus plicatus, Hall	x	x
Dichocrinus striatus, Owen & Shumard	x
Dichocrinus sp?	x	x	.	.	.	.	.	.
Dichocrinus sp.	x	x	.	.	.	.	.	.
Dorycrinus parvus (Shumard)
Dorycrinus intermedius, Meek & Worthen	x	x
Dorycrinus remeri, Meek & Worthen	x
Dorycrinus cornigerus (Hall)	x
Dorycrinus subaculeatus (Hall)
Dorycrinus unicornis (Owen & Shumard)	x	x	x	x	.	.	.	.
Dorycrinus missouriensis (Shumard)	x
Dorycrinus inflatus, Rowley
Dorycrinus sp?
Glyptocrinus forshellii, Miller	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Glyptocrinus sp?	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.		Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouveau.	Lower Burlington.					Upper Burlington.		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
<i>Steganocrinus pentagonus</i> (Hall).....	x	x	..	..	..	..
<i>Steganocrinus sculptus</i> (Hall).....	x	x	x	..	..	..
<i>Strotocrinus glyptus</i> (Hall).....	x	x	
<i>Strotocrinus regalis</i> (Hall).....	x	x	x	
<i>Symbathocrinus brevis</i> , Meek & Worthen.....	x	..	..	..	..	..	..
<i>Symbathocrinus dentatus</i> , Owen & Shumard.....	x	x	..	
<i>Symbathocrinus papillatus</i> , Owen & Shumard.....	
<i>Symbathocrinus wortheni</i> , Hall.....	x	x	..	
<i>Symbathocrinus</i> sp?	x	x	..	
<i>Symbathocrinus</i> sp?	x	..	..	..	..	..
<i>Taxocrinus themii</i> (Hall).....	x	..	..	..	..	..	..
<i>Teleocrinus agilops</i> (Hall).....	x	x	
<i>Teleocrinus liratus</i> (Hall).....	x	x	
<i>Teleocrinus umbrosus</i> (Hall).....	x	x	
<i>Teleocrinus</i> sp?.....	x	x	
<i>Metablastus wortheni</i> (Hall)?.....	x	..	..	..	..
<i>Metablastus lineatus</i> (Shumard).....	x	x	..	..	..	..	..
<i>Metablastus</i> sp?.....	x	
<i>Woodocrinus elegans</i> (Hall).....	x	..	..	..
<i>Woodocrinus troostanus</i> , Meek & Worthen.....	x	x	..	..
<i>Woodocrinus</i> sp?.....	x	x	..	..
BRYOZOANS:																					
<i>Coscinium latum</i> , Ulrich.....	x	..	..	..	..	..	..
<i>Evactinopora grandis</i> , Meek & Worthen.....	x	x	..	..	..	..
<i>Evactinopora radiata</i> , Meek & Worthen.....	x	..	..	..
<i>Evactinopora sexradiata</i> , Meek & Worthen.....	
<i>Fenestella burlingtonensis</i> , Ulrich.....	x	..	..
<i>Fenestella filistriata</i> , Ulrich.....	x	x	..	..	x	x	x	
<i>Leioclema</i> sp?.....	x	x	..	..	..	..	..	..	..	x	x	..	..	..	..	..
<i>Lyropora retrorsa</i> , Meek & Worthen.....	x	..	..	..	..
<i>Polypora burlingtonensis</i> , Ulrich.....	x	x	..	..	..	..	..
<i>Rhombopora</i> sp?.....	x	..	..	..	..	..	..
<i>Tæniodictya ramulosa</i> , Ulrich.....	x	x	..	
BRACHIOPODS:																					
<i>Ambocœlia minuta</i> , White.....	x	x	x	..	..	..	..	..	..	..	..	..	..	..	..
<i>Ambocœlia</i> sp?.....	x	x	..	..	..	..
<i>Athyris incrassata</i> , Hall.....	x	x	..	..
<i>Athyris lamellosa</i> , Hall.....	x	x	x	x	x	x	..	x	x	
<i>Athyris</i> sp?.....	
<i>Athyris hannibalensis</i> , Swallow.....	x	x	x	..	..	x	x	..	..	..	..	..	..	..	..	x	
<i>Athyris</i> sp?.....	x	x	..	..	..	..
<i>Athyris</i> sp?.....	x	x	..	..	..	..
<i>Atrypa nodostriata</i> , Hall.....	
<i>Atrypa</i> sp?.....	..	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Camarophoria</i> sp?.....	x	x	..	..	..
<i>Centronella rowleyi</i> (Worthen).....	x	x	x	..	..	..
<i>Centronella</i> sp?.....	x	x	..	..	..	..
<i>Chonetes geniculatus</i> , White.....	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Chonetes logani</i> , Norwood & Pratten.....	x	x	..	..	..	..	..
<i>Chonetes ornatus</i> , Shumard.....	x	x	x	..	..	x	..	..	..	..	..	..	..	..	..	..
<i>Chonetes</i> sp?.....	x	..	..	..	..
<i>Crania rowleyi</i> , Gurley.....	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Crania</i> sp?.....	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Crania</i> sp?.....	x	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Crania</i> sp?.....	
<i>Cyrtina acutirostris</i> , Shumard.....	x	x	x	x	..	..	..	..	..	..	..	..	..	..	..
<i>Cyrtina burlingtonensis</i> , Rowley.....	x	x	..	..	..	..	..
<i>Discina</i> sp?.....	x	x	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>Discina melle</i> , Hall.....	x	..	..	..	..	..	..

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

SPECIES.	Hudson.		Niagara.		Hamilton.		Louisiana.				Hannibal.		Chouteau.		Lower Burlington.				Upper Burlington.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<i>Streptorhynchus crenistriatus?</i> Phillips.																	x		x	
<i>Streptorhynchus flitextum?</i> Hall.	x																			
<i>Streptorhynchus lens</i> (White).					x	x	x													
<i>Streptorhynchus planumbonum</i> (Hall).	x																			
<i>Streptorhynchus subplanum</i> (Conrad).		x	x	x																
<i>Streptorhynchus</i> sp?.																				
<i>Strophalosia scintilla</i> , Beacher.						x	x													
<i>Strophalosia beecheri</i> , Rowley.						x														
<i>Strophomena alternata</i> , Conrad.	x					x														
<i>Strophomena rhomboidalis</i> , Wilkens.		x	x																	
<i>Strophomena rhomboidalis</i> var.															x	x	x	x	x	
<i>Syringothyris typus</i> , Hall.																				
<i>Syringothyris carteri</i> (Hall).					x	x	x	x			x									
<i>Terebratula burlingtonensis</i> , White.															x	x	x			
<i>Terebratula</i> sp?.															x	x				
<i>Terebratula</i> sp?.															x					
<i>Terebratula</i> sp?.						x	x				x									
<i>Terebratula</i> sp?.						x	x													
<i>Zygospira putilla</i> , Hall.		x																		
<i>Zygospira recurvirostra</i> , Hall.	x																			
LAMELLI BRANCHES:																				
<i>Aviculopecten burlingtonensis</i> , Meek & Worthen.															x	x				
<i>Aviculopecten circulus</i> , Shumard.																				
<i>Cardiomorpha</i> sp?.																x				
<i>Cardiopsis</i> sp?.															x					
<i>Conocardium</i> sp?.																x				
<i>Crenipecten</i> sp?.																x				
<i>Crenipecten</i> sp?.																x				
<i>Cypricardella</i> sp?.																x				
<i>Cypricardia</i> sp?.																x				
<i>Dexiobia</i> sp?.											x									
<i>Edmondia burlingtonensis</i> , White & Whitfield.																x				
<i>Edmondia nuptialis</i> , Winchell.																x				
<i>Grammysia hannibalensis</i> (Shumard).						x					x									
<i>Nuculites</i> sp?.							x									x				
<i>Pernopecten cooperensis</i> (Shumard).												x								
<i>Pernopecten</i> sp?.																	x			
<i>Prothyris meeki</i> , Winchell.																	x			
<i>Sanguinolites</i> sp?.																	x			
<i>Sanguinolites</i> sp?.																		x		
<i>Sphenotus</i> sp?.																			x	
<i>Lithophaga occidentalis</i> , White & Whitfield.																x				
PTEROPODS:																				
<i>Conularia</i> sp?.	x																			
<i>Conularia</i> sp?.								x												
<i>Conularia victa?</i> White.																x				
<i>Tentaculites</i> sp?.			x																	
GASTEROPODS:																				
<i>Bellerophon</i> sp?.		x																		
<i>Bellerophon bilabiatus</i> , White & Whitfield.																x	x			
<i>Callonema</i> sp?.						x	x													
<i>Cyclonema</i> sp?.		x	x																	
<i>Cyrtolites</i> sp?.		x																		
<i>Dentalium</i> sp?.																x				
<i>Planerotinus paradoxus</i> , Winchell.																x				
<i>Omphalotrochus springvalensis</i> (White).														x	x	x				
<i>Straparollus latus</i> , Hall.													x	x	x	x	x			
<i>Straparollus ammon</i> (White & Whitfield).																x	x			

TABLE SHOWING VERTICAL RANGE OF FOSSILS—CONTINUED.

[illegible]

The above table embraces all the evidence thus far obtained at the locality in question.

In considering the faunal features of the succession the interest centers in the characters of the fauna of the Kinderhook and of its several parts. Three problems are presented: (1) the general facies of the fauna as a whole, and the parts giving it its predominant phase; (2) the character and relations of the basal fauna, and (3) the upper limit, if any can be made out, of the fauna most characteristic of the formation.

(1) *General Faunal Facies*.—Heretofore the attempt has been always to treat the organic remains contained in the Kinderhook, "Chouteau" or "Chemung," as belonging to a single fauna. Owing to the heterogeneous beds that have been placed together in the formation it has been the chief mission of later work to take out from time to time various parts which were originally correlated with this terrane. Thus gradually the formation at its typical localities has finally come to be more clearly understood.

Regarding the "Kinderhook" as made up of three subdivisions, the Louisiana limestone, the Hannibal shale and the Chouteau limestone (in its original sense) the fauna contained when deprived of elements which have in reality no relation to it whatever, presents a very different facies from that generally ascribed to it. With the light of definite zonal distribution of the organic forms there appears to be, instead of a single compact and characteristic group of forms, two very distinct faunas, as is nowhere more clearly shown than in the locality which can be regarded as typical and in which the faunal zones have been determined with considerable accuracy and corroborated by evidence from other districts. Owing to indefinite knowledge regarding the exact horizons from which the various genera and species have been found in the past the general faunal facies of the "Kinderhook" has heretofore borne a composite and not a pure physiognomy.

A tabular arrangement of all the species of fossils that are recognized at a typical locality for the Kinderhook, and that range from the Hudson to the Upper Burlington, has disclosed very clearly some important facts which heretofore have been overlooked. The first of these features is the close affinity of the faunas, from the lower two members of the Kinderhook, with the underlying Devonian, and the second is the sharpness with which the lower fauna stops at the base of the Chouteau,

and the abruptness with which an entirely new fauna begins at that level.

(2) *Character and Relations of the Lower Fauna.*—The components of this fauna comprise those forms which, as already noted, occur in the Louisiana limestone and the Hannibal shales. For the present only the species from the former need occupy attention.

As a whole the fauna is clearly closely related to that occurring in the Western Hamilton. Some of the species, though bearing different names, are in reality identical with typical forms from that formation. Heretofore the fossils have been found, with few exceptions, perhaps, only in the basal portion of what is called the Louisiana limestone, in number 6, a thin sandy layer which is lithologically similar to the partings in the limestone itself. The results of the latest investigations show that many of the forms extend upward, some of them passing practically unchanged through the whole Louisiana to the top of the Hannibal. Not a single species of this fauna appears to occur in the overlying layer which has been regarded as the equivalent of the Chouteau. Many of the forms also range downward into the dark colored shale below, which is regarded as of Devonian age and which is here separated into two parts. A short distance away the shale becomes much thicker.

The general impression derived from the table is that the zones 5 to 8 inclusive are faunally very closely related, and that the higher ones, 9 to 11, also have close affinities with the lower zones. It may be noted in this connection that no special effort has been made to determine the full faunas of the higher beds, as the critical evidence that was needed was in regard to the fauna of the Louisiana (Lithographic) limestone. The shales have, however, proved to be remarkably barren in organic remains. Towards the top where they become sandy a number of the lower species are found. That the shales do not appear to be fossiliferous is not remarkable. Since they manifestly do not contain abundant remains in a good state of preservation they have not been searched so carefully by fossil collectors as have the other beds. At Burlington, Iowa, where there are excellent exposures and numerous active local collectors, besides a host of transient ones, the same shales remained for half a century without a fauna to be ascribed to them. But of late they have been shown to be abundantly

supplied with fossils. Without exception they appear to be characteristic Devonian forms. As yet, however, the fauna has not been studied sufficiently to be specifically listed, but the brachiopods are mostly very similar to, if not identical with, the species found in undoubted Devonian shales farther northward in the same state. The cephalopods are represented by large forms of *Cyrtoceras*, *Gomphoceras*, and *Phragmoceras*. One belonging to the latter genus may prove to be Winchell's *P. expansus*. Another very characteristic phase of the fauna is the non-trilobitic crustaceans, of which a very considerable number have been found. They have very close affinities to *Tropidocaris* and *Amphipeltis*.

It appears, then, that a well defined Devonian fauna extends up to the top of the Hannibal shales in northeastern Missouri, at Louisiana especially, and that the "Kinderhook" shales of southeastern Iowa, as typically developed at Burlington, and as corresponding in great part to the Hannibal shales, carry no other remains than those of pronounced Devonian types. The upper part of the section usually regarded as Kinderhook at Burlington, in fact all the thin limestone and sandstone bands down to the great body of argillaceous shales may be more properly regarded as the equivalent of the Chouteau limestone, that is, the uppermost member of the so-called Kinderhook in Missouri.

(3) *Upper Limit of the Louisiana Fauna.*—One reason that the fauna of the Chouteau (original) limestone has not been better understood than it has, in its relation to the faunas occurring lower in the so-called Kinderhook, and higher in the Burlington limestone, has been that in the localities where the lower Carboniferous has been most thoroughly and widely studied along the Mississippi river, the Chouteau, as commonly recognized, nowhere crops out along the great stream, except, perhaps, in the vicinity of the town of Louisiana where, under the typical Burlington, there are nine feet of earthy limestone which has been considered a part of the latter, but which is now believed to be the attenuated edge of the Chouteau, or its equivalent. In the same county the Chouteau attains a maximum thickness of twenty-five to thirty feet.

In the table given there is: (1) The species that come up from below to the base of the Chouteau, (2) those starting in the Chouteau and ranging upward, (3) the forms starting in the basal member of the Burlington limestone, and (4) the

species which comprise a lower fauna in the midst of a higher.

The most striking features in the vertical distribution of the fossils shown in the table given are: (1) The upper fauna nowhere extends beneath the base of the Chouteau (No. 12) and the lower fauna nowhere rises above the same line; (2) all the species belonging to the fauna beginning in the Chouteau extend upward into the Burlington; (3) while in the Burlington many new forms appear there is no immediate replacement of the older forms; (4) the many new species which appear in the second bed of the Burlington (No. 14) are largely so-called Kinderhook forms, not altogether from the Chouteau, but from the limestones which occur just beneath the Burlington limestone at the city of Burlington.

From a consideration of both tabular arrangements the following general conclusions are deduced:

1. The most marked change in the succession of faunas in the entire sequence of rocks commonly known as the Lower Carboniferous, or "Subcarboniferous" as represented along the Mississippi river is at the base of the Chouteau limestone (limited). At this horizon there is so great a faunal hiatus that there is scarcely a species that is common to the beds on either side.

2. That instead of the so-called Kinderhook containing in its fauna a mingling of Devonian and Carboniferous types there are really two faunas that are perfectly distinct, well-defined and not merging into each other. The one is characteristically Devonian in character and the other as strikingly Carboniferous in its general facies.

3. That the basal line of the Lower Carboniferous or Mississippian series is the base of the Chouteau limestone and the lower member of the four-fold series contains only one formation instead of the three heretofore commonly ascribed to it.

4. That the early reference of a part of the so-called Kinderhook or "Chemung" to the Devonian was correct in fact, though made through erroneous correlations.

5. That the evidence afforded by the faunas of the region is in close accord with the facts obtained regarding discordant sedimentation, and the stratigraphical and lithological characters of the formations.

NATURAL GAS IN THE DRIFT OF IOWA.

BY A. G. LEONARD.

The finding of natural gas in the Pleistocene deposits of the state has been noted from time to time during the past decade. The first mention of its occurrence, as far as known, appeared in the report of the state mine inspector* for the years 1886 and 1887.

A brief account is therein given of its discovery at Herndon, Guthrie county, in 1886, while boring a hole for water. Six wells are reported as yielding a good flow of gas, which was utilized for cooking and heating purposes. The presence of gas at Herndon is also mentioned by McGee in the Eleventh Annual Report of the United States Geological Survey.† In the proceedings of the Iowa Academy of Sciences for 1890-1891 Mr. F. M. Witter‡ reports the discovery of natural gas near Letts, Louisa county. Seven wells sunk for water yielded it, and the gas from one furnished fuel and light for four families. Its probable source is stated to be from the vegetable matter buried in the drift.

R. Ellsworth Call in the Monthly Review of the Iowa Weather and Crop Service for November, 1892,§ reports that there are many instances of the discovery of natural gas in the drift of the state while exploring for coal or for artesian waters. The wells at Herndon and Letts are noted as are also those at Dawson, in Dallas county.

In all cases the gas is thought to have come from the vegetable debris of the glacial deposits.

Among the other localities where this natural fuel has been found may be mentioned one about seven miles northeast of Des Moines and another not far from Stanhope, in Hamilton county. For several years gas from the well at the latter place has been utilized for fuel.

*Report state mine inspector, 1887, pp. 169-170.

†Eleventh Ann. Rept., 1889-1890, part I, p. 595.

‡Iowa Acad. Sci., vol. I, part II, pp. 68-70.

§Monthly Rev. Iowa Weather and Crop Serv., vol. III, Nov., 1892, p. 6-7.

From the above it will be seen that the occurrence of natural gas in the glacial deposits of the state is not an uncommon event and that a number of different localities have yielded it in small amounts.

Before taking up the subject of the source and origin of the natural gas it will be well to describe more in detail some of the localities mentioned above, in order that the conditions under which the gas is found may be clearly in mind. Only after such a careful review of the facts connected with the various occurrences is it possible to form an opinion as to the probable source. A comparison of the Iowa localities with those of other states will also prove helpful in this connection.

The Herndon wells were the first in the state, so far as known, to yield gas in any considerable amount. Its discovery is thus described in the mine inspector's report already referred to: In the month of October, 1886, Mr. G. Gardner was boring a hole for water and had reached a depth of about 120 feet. Work had been stopped for the night and the family was at supper when suddenly a loud noise was heard like that made by steam escaping from a boiler, and on going out to the well it was found discharging large quantities of gas, sand and gravel. This first well was not used on account of the difficulty experienced in getting it tubed so as to shut out the sand. A second was abandoned for the same reason, but the third, put down by Mr. H. C. Booth, was more successful. The gas was conducted into the house and used for heating and cooking purposes. Six wells have been bored here and a good strong flow obtained in all of them. In two of these the flow still continues but the others have become choked up with sand. The depth of the wells varies from 120 to 140 feet. The gas is found in a layer of sand and above this the following beds occur:

	FEET.
Black loam	6
Yellow clay	6
Blue clay	108

One well at this locality is reported to have reached a depth of over 219 feet and went a considerable distance into the coal measures, but it yielded no gas. Another well, which for a time had a good flow of gas, was located near the town of Yale, five miles south of Herndon.

The only direct evidence of any considerable accumulations of vegetable material in the drift of this region is furnished by

the record of an old water well near Yale, where a forest bed some three feet in thickness was passed through. It was overlaid by forty-two feet of yellow, blue and red clay and beneath was four or five feet of blue clay. Below the latter there is from two to ten feet of sand. The gas at Herndon is found in a layer of sand at the base of the drift and probably directly overlying the coal measure shales.

During the past summer the wells near Dawson were visited and a few additional facts secured concerning them. Dawson is located near the northern border of Dallas county and about eight miles east of Herndon. The wells are three-quarters of a mile south of town and the gas occurs under much the same conditions as at the locality already mentioned. Five holes have been drilled here, one being put down in 1888 and the other four in 1891. They have a depth of from 110 to 115 feet, passing through the drift clay into a bed of sand and gravel. The gas is found in the gravel layer below a compact blue clay. A coal shaft just east of Dawson shows sixty-four feet of this blue clay. During the past summer the first well, bored eight years ago, was tested to find the pressure, the result being that this was ascertained to be 24 to 25 pounds to the square inch. The gas burned with a flame 15 to 20 feet high. It was piped to town, and for a time supplied one of the houses with fuel. It was also used in the kilns of a brick plant a short distance east of the station. Three of the wells still have a good flow but are no longer used.

In this connection mention should perhaps be made of the gas found in considerable quantity in the water supply of Perry, six miles east of Dawson. Perry secures its supply from four wells located in the southern part of town. These wells have a depth of 115 feet. Gravel is struck 70 feet below the surface and the lower 45 feet is through this material. The water for a time came to the surface and overflowed, but after a number of wells were sunk and it had been pumped from the city wells the head was lowered, and now the water rises only to within 5 or 6 feet of the surface. The amount of gas in the water is so great that Mr. J. W. Rodefer has for some time been experimenting for the purpose of extracting it for use in heating and lighting. He has succeeded in doing this on a comparatively small scale, and the gas thus separated is utilized to furnish fuel and light to his office. Can it be extracted by a sufficiently inexpensive method, and in large enough quantity,

this natural gas contained in its water supply may yet furnish Perry with a convenient fuel.

In the case of the wells near Letts, Louisa county, the conditions appear to be slightly different. They have a depth ranging from 90 to 125 feet, but do not reach the base of the drift, since in a number of instances the rock in this region has not been struck at 280 feet below the surface. "At a depth of from 6 to 25 feet below the gas a good, constant supply of water is obtained. It seems to be very easy to shut off the gas by the rapid sinking of the casing in a sort of blue clay with some sand, in which the gas is thought to be stored. The clay seems to form a tube as the drill and casing descend, and this prevents the gas from getting into the well unless it is given a little time at the right place. The country for miles around is full of wells which are all believed to be sunk to the water below the gas, without discovering the latter for reasons given above." From the foregoing statements it is apparent that the gas at this locality does not occur in a well defined sand bed, but is distributed through the upper portion of the Pleistocene deposits, being usually found at a depth of about 100 feet. There seems to be abundant evidence of the presence of extensive accumulations of vegetable material in the drift of this region.

But Iowa is not the only state where natural gas is found in the surface deposits, for it occurs also in the drift of Ohio, Indiana and Illinois. Its occurrence in Ohio is mentioned by Orton.* On the southern margin of the drift of that state and for twenty to forty miles back from its border there are in many parts of the state considerable accumulations of vegetable matter covered by later deposits of the drift period. Wells dug into these deposits often strike quite extensive accumulations of one or the other of the two gases given off by the decomposition of this buried vegetation, namely, carbon dioxide and marsh gas. Sometimes carbon dioxide, or carbonic acid gas as it is commonly called, is found in all the wells of the neighborhood and no water well can be completed on account of its presence. It is not an uncommon thing for well diggers to lose their lives from this deadly "choke damp."

Calvin has noted several instances in Iowa where this gas escaped with considerable force from holes bored for water.

*Geol. Surv. of Ohio, vol. VI, pp. 772-775.

Much more frequently marsh gas is struck in the vegetable deposits (of Ohio) and sometimes escapes in large volume and with great force when first released. It not infrequently gives rise to a small but persistent supply. Gas wells are of common occurrence in all the border areas above mentioned.

In Illinois natural gas in the drift has been found in commercially valuable quantities at Bloomington, Kankakee, Mendota, and other points.

The reports of the Indiana survey also contain accounts of the discovery of gas in the superficial deposits of that state.

From what has been said above it will be seen that it is by no means an uncommon thing to find gas in the Pleistocene deposits. It has been discovered at a number of different points in at least four states and doubtless there are unrecorded occurrences in other parts of the country.

We are now prepared to consider the question as to the source of this natural gas and later its origin.

There are two possible sources of the gas found in the drift. (1) It may have been derived from the underlying rock and the drift then serve simply as a reservoir for its accumulation and storage, or (2) it may have been derived from the vegetable accumulations of the drift and thus have its source in the Pleistocene deposits where it is now found. The latter source is doubtless much the more common and in most instances there is little doubt that the gas has been derived from the decomposition of the vegetable remains in the drift. But examples of the drift serving as a reservoir only, are occasionally found. Thus, Orton mentions several such instances in Ohio and it is possible, though hardly probable, that at Herndon and Dawson the gas has been derived from the underlying coal measures shales.

That it may have such a source the gas-bearing rocks must be overlaid by porous beds of drift. Then during the long periods since they have had this relation the porous beds have become charged with gas when there were suitable conditions of level. As we have already seen the arrangement of the beds at Herndon and Dawson are such that it is possible that the gas might be derived from the rocks underlying the drift sheet. At both of these localities the gas occurs in a stratum of sand and gravel at the base of the drift and apparently directly overlying the coal measures. As already stated the wells have a depth

of from 110 to 140 feet. Nowhere in this immediate neighborhood is the drift known to have a greater depth than this. At Dawson a coal shaft shows the superficial deposits to be eighty feet thick at that point. At Angus, a few miles northeast of Dawson, there is a thickness of fifty to 100 feet and in southern Greene county borings show between sixty and seventy feet of drift. There seems to be considerable evidence, therefore, that the gravel is at the base of glacial deposits and that it rests directly on the coal measure shales. In this case it would be possible that the gas, originating in these black carbonaceous shales, may have passed up into and accumulated in the gravel and sand beds above.

But it seems much more probable that the gas at Herndon and Dawson has its source in the vegetable accumulations of the drift, as is undoubtedly true for the gas at Letts.

It is not necessary to suppose that it has been formed directly in the place where it is now found. It may have originated from the decomposition of vegetable material some considerable distance off and later have diffused itself laterally through the gravel beds until reaching a place favorable for its accumulation.

There is another interesting fact concerning the distribution of these gas wells. They are found not far from the border of the upper drift sheet of the region. Thus, for example, at Dawson and Herndon the wells are only a few miles back from the edge of the Wisconsin lobe and at Letts the Illinois ice seems to have extended but a short distance in the west. Orton mentions the same fact concerning the distribution of wells in Ohio, where as already stated, they are found along the border of the glacial deposits or back twenty to forty miles.

The most favorable conditions for the preservation of forest beds and like accumulations of vegetable material would seem to be near the edge of the ice, where it was the thinnest, and where, during its advance, there would have been less disturbance of the materials beneath. During its advance only a comparatively few miles of the ice sheet would pass over the drift near its border, while back 50 or 75 miles the ice would doubtless be considerably thicker and a vastly greater amount of ice would pass over the surface, and as a result the underlying deposits would be more disturbed. The forest bed, if present, might be carried away or mingled with the clay of the drift.

Concerning the origin of natural gas little need be said. It is now generally admitted by all geologists and most chemists

that the various bitumens, including natural gas, are genetically connected with and are closely allied to marsh gas, and that they are produced by the natural decomposition of organic tissue. Natural gas closely resembles in composition the inflammable marsh gas which is often observed coming from the muddy bottoms of stagnant ponds. The following analysis, giving the mean results of seven analyses made for the United States Geological survey by Prof. C. C. Haward, will show the composition of natural gas:

Marsh gas.....	93.36
Nitrogen	3.28
Hydrogen	1.76
Carbon monoxide.....	.53
Oxygen .....	.29
Olefiant gas .....	.28
Carbon dioxide.....	.25
Hydrogen sulphide.....	.18
Total	100.03

Marsh gas, the principal constituent, is a simple compound of carbon and hydrogen in the proportions of 75 per cent of the former to 25 per cent of the latter.

The natural gas of the Pleistocene deposits of Iowa is then simply the product of the decomposition of the vegetable remains buried in the drift.

RESULTS OF RECENT GEOLOGICAL WORK IN MADISON COUNTY.

BY J. L. TILTON.

OUTLINE.

1. The geological formations of the county.
2. The distribution of the alluvium, loess and drift.
3. The relation of present drainage to preglacial drainage.
4. Terraces.
5. The areas occupied by the Des Moines and Missourian stages of the coal measures.
6. The transition from the Des Moines to the Missourian stage.

It is intended in this paper to state briefly some of the geological features of Madison county as observed during the

past summer. For a more detailed description, reference may be made to the complete report in the next volume of the "Iowa Geological Survey."

The county is thoroughly drained, the uplands well dissected by ravines that have left no swamps. The streams have well established grades over loess and drift. Only at the heads of smaller ravines is present erosion still in progress. Such a drift topography is again approaching maturity.

Above the flood plains of the streams a line of low, rounded knolls rises about six feet. These constitute a river terrace in the normal development and mark the highest limit of spring floods. About fifty feet above the bed of Middle river the remains of a second terrace are found in various places along the stream. At various points terrace-like places appear along the hillsides. Some of these are undoubtedly dependent on the resistant character of underlying strata. As a whole they bear so little relation one to another and to the river bed, that they are judged not to be terraces dependent on former stages of water in the stream, but of local character dependent on the differential weathering of the hillsides.

The geological formations of the county are given in the following table:

CLASSIFICATION OF FORMATIONS IN MADISON COUNTY.

GROUP.	SYSTEM.	SERIES	STAGE.	SUBSTAGE.
Cenozoic.	Pleistocene.	Recent.		Alluvium.
		Glacial.	Iowan.	Loess.
			Kansan.	Drift.
		Upper.	Missourian. Represented by the Winterset limestone.	
Paleozoic.	Carboniferous		Des Moines.	

Alluvial deposit is to be found in the broad river valleys. It generally lies on loess extending down into the river bottoms.

The loess deposit of the county occupies the divides, and extends over the hillsides into the river valleys. It is quite thin over the entire county, excepting east of Barney, where large hills of loess are banked against the adjacent Missourian limestone. The loess here is stratified, seeming to be made up of wash from the unstratified loess. In the east central and northeastern parts of the county the loess is more sandy than as usually found. The loess consists of two parts, an upper and a lower; the lower is more clayey than the upper, but no soil line has been observed between the two parts within the bounds of the county. The line between the two may have some relation to the soil line first observed at Churchville, Warren county, by Bain, and to the line of separation between the upper and lower loess at Indianola described in the report on the "Geology of Warren county."*

The Kansan drift is very heavy in the northeastern, southeastern and southwestern parts of the county. It consists of the usual reddish-brown gravel containing subangular water-worn pebbles of various light colored granite and quartz, together with greenstone and reddish quartzite pebbles and boulders. Below this gravel is a clay with numerous pebbles scattered through it, that, under the action of running water, form numerous little pot-holes in the beds of ravines that cut into this clay in the southeastern part of the county. There are no characteristics at present known whereby the relation of this lower part of this Kansan drift to the sub-Aftonian, or Albertan, drift may be determined.

There is no Wisconsin drift within the limits of the county, but the loess on the hills in the northeastern part of the county is quite sandy. Near the boundary between Lee and Jefferson townships, the northeastern townships, various outcrops of Des Moines strata protrude from the hillsides, while in the western part of Jefferson township they are concealed by the drift.

The loess lies unconformably on the Kansan drift, and the drift unconformably on the Carboniferous strata.

The relation of the drift to the underlying strata reveals the general plan of the preglacial drainage as contrasted with the present drainage.

* "Geology of Warren County," in Iowa Geological Survey, vol. V, p. 318.

The dotted line represents the boundary line between the surface outcrops of the Des Moines strata on the east and the Winterset strata on the west. The main points of difference

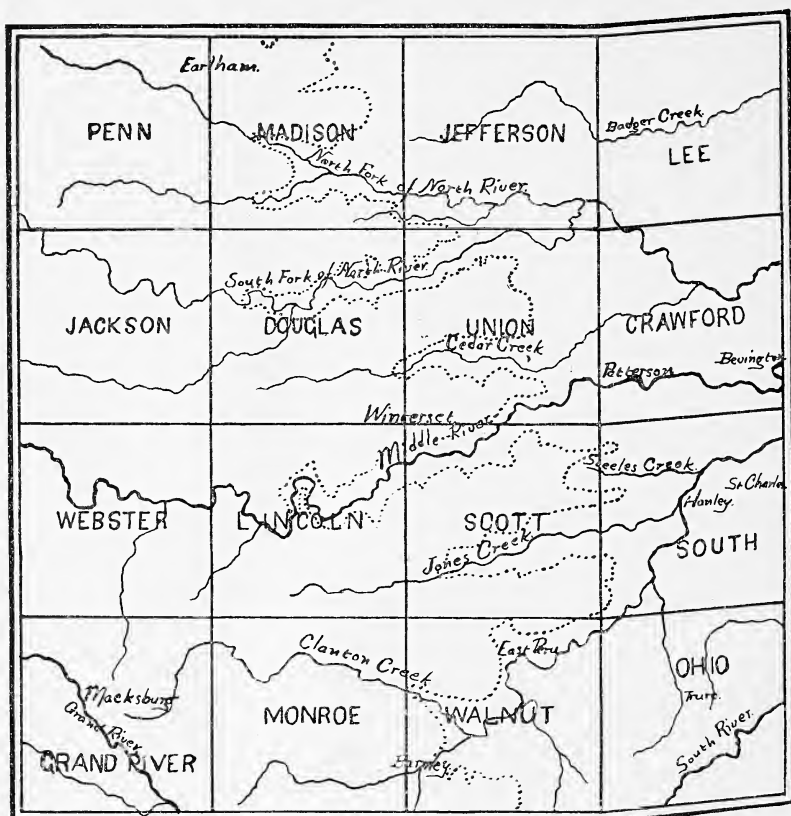


Fig. 1. Present drainage of Madison county.

are as follows: The drainage of Jefferson township was south-eastward along the front of the Winterset limestone to North river. Because of the drift, Badger creek now flows northeastward over the drift across Jefferson township, then southeastward across the pre-Kansan divide, then eastward across Lee township. The stream seems to follow pre-Kansan ravines, but does not cut through the drift.

A preglacial valley extends southwestward from the western part of Lincoln township across the southeastern part of Webster township and thence across Grand River township. This old valley is now completely filled by drift, and the drainage, which was formerly turned toward Middle river, is now turned

southeastward into Grand river, a stream that is post Kansan in Madison county. Middle river, west of Lincoln township, formerly uniting in section 21 of Lincoln township with the

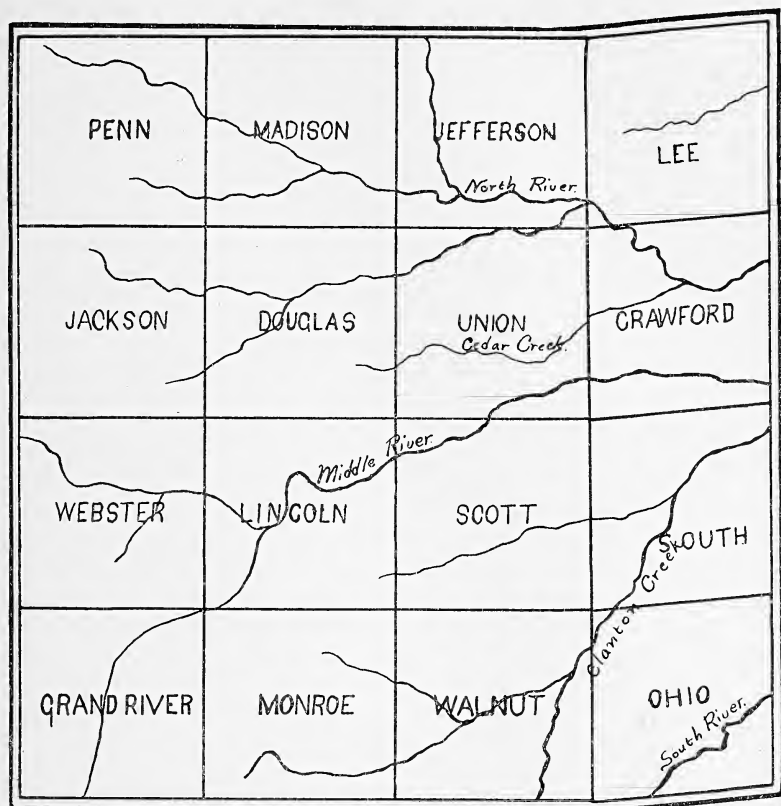


Fig. 2. The lines of preglacial drainage in Madison county.

stream from Grand River township, flowed in a large curve northward and then eastward, leaving in the bow thus formed that delightful and somewhat romantic "Devil's Backbone."

East of Barney the main part of Clanton creek seems to have flowed northward across section 35 of Walnut township.

The following streams are in preglacial valleys of their own: North river, Middle river, South river, Clanton creek, and the principal parts of Cedar creek, Jones creek and Steels branch; but the valleys are all much modified by the drift, and there is evidence of long-continued erosion during the time that was post-Kansan and preloessal. The smaller ravines forming the heads of the larger ravines are post-glacial.

The geest, the weathered coal measure surface of preglacial times, forms no important part of the soil. It is completely obscured by drift and loess, excepting where exposed by erosion.

The strata underlying the drift in the eastern part of the county belongs to the Des Moines stage of the coal measures. The strata underlying the drift in the western part of the county belongs to the Missourian stage of the coal measures. The dividing line between the surface outcrops of these stages may be traced as an irregular line across Madison township, the northeastern part of Jefferson, the central part of Douglas, Union and Lincoln townships, the eastern part of Scott and the central part of Walnut townships. (See figure 1.) The general surface of the limestone to the west of this line is higher than the surface of the shales east. This difference in elevation, together with the presence of preglacial valleys along the eastern margin of the Missouri limestone except in the divide just south of Patterson, make the limestone form an escarpment across the county.

East of the dividing line the strata are generally clayey or sandy shale, but there are outcrops of a layer of limestone from one and a half to two and a half feet thick, especially important in the neighborhood of Truro, hence here called the Truro limestone. It outcrops along South river at an altitude of seventy feet above the river bed, and on both sides of Clanton creek valley. It outcrops along the hillsides in Crawford township, and appears near the crests of divides between Lee and Jefferson townships. Its distance below the base of the Winterset limestone is eighty feet.

While in the Des Moines shales, unconformity is common, and in the sandy shales south of Patterson ripple-marks are to be found only forty feet below the Winterset limestone, there is no unconformity whatever between the base of the Winterset limestone and the uppermost Des Moines shales. This gives evidence that, just prior to the time when the Winterset limestone was deposited in the county, the shore line was farther inland (east or northeast) of the present limits of the limestone, and, with the gradation from sandy shales with ripple-marks, through clayey shales to Winterset limestone, sustains the conclusion previously advanced by Keyes that the Missourian limestone was formed in an advancing sea.

The succession of strata in the Winterset limestone is as follows, with uniform general characteristics throughout the county:

- 13 ft. Limestone, very shaly above, lower part heavier but with varying thickness of marly partings. This forms the base of the Missourian limestone.
- 2 ft. 8 in. Shale, clayey, gray above, black below.
- 4 in. Limestone; dense, jointed.
- 9 in. Shale, clayey, gray.
- 6 in. Limestone, irregular, gray, fossiliferous.
- 2 ft. 6 in. Shale, clayey, gray.
- 1 ft. 9 in. Limestone, irregularly concretionary.
- 9 ft. 6 in. Sandstone, shaly, gray.

In section 22 of Lincoln township the shales that are clayey in outcrops found in the northern part of Scott township, are calcareous shales, giving evidence clearly visible that the uppermost part of the Des Moines shales gradually changes into limestone toward the southwest. This necessary condition has been generally recognized concerning the Des Moines shales as a whole, but no transition now visible has to my knowledge been pointed out, unless it be in the deep well records of Montgomery county.

While there may be a marked difference in fauna between that of the Des Moines stage and that of the Missourian,* such distinctions as exist in the fossils seem satisfactorily referred to oscillation causing varying conditions of depth in the water with no very marked break. When the bottom of the sea was depressed, the deeper water fauna migrated into this deepening water. When the bottom was elevated, the deeper water fauna moved farther out to conditions more favorable, while their place was taken by a shallow water fauna. Of course if the Winterset limestone, and its shore equivalent, were laid down in an advancing sea, there must have been unconformity beneath the deposits somewhere, but not where the strata are still existing in Madison county. The changes in depth of water are accompanied by changes in the character of the strata. These

*University Geological Survey of Kansas, vol. I, p. 181.

changes, based on the succession of strata within the county, may be represented in the on following diagram:

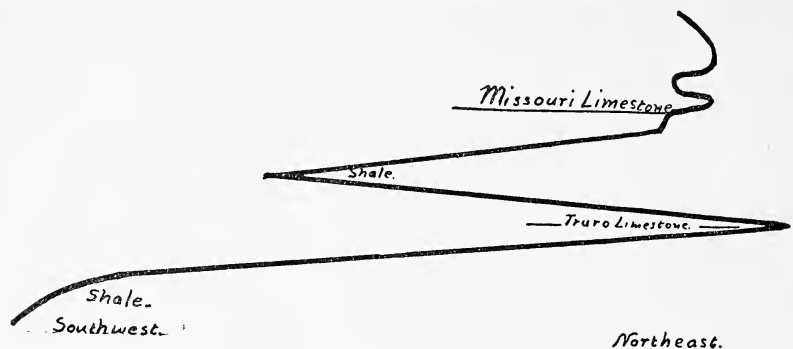


Fig. 3. Diagram representing the relative positions of the shore lines as indicated by the general character of the strata within Madison county.

NOTE.—A later comparison of outcrops proves that those shales in the upper Des Moines which are mentioned in this paper as calcareous, lie a few feet above those to the east with which they were compared; hence the local evidence mentioned that the upper part of the Des Moines shales becomes calcareous toward the west is wanting.—AUTHOR.

DRIFT SECTION AT OELWEIN, IOWA.

BY GRANT E. FINCH.

Just outside the limits of the growing town of Oelwein, Iowa, to the southeast, the Chicago Great Western Railroad company, in order to lessen a troublesome grade, have excavated a cut nearly a mile in length. At the end farthest from the town, where it passes diagonally through a ridge, it has a maximum thickness of thirty-two feet. This ridge has a northwest-southeast trend, and is one of the ordinary gentle swells characteristic of the drift of this region.

To pass along the front of so extensive a section, twice the depth of ordinary drift cuts, fresh and untarnished by sun and rain, is a pleasure to any one, whether geologist or not. The great variety of colors—strata black, brown, gray, blue, green, and several shades of yellow; the distribution of boulders like plums in a Christmas pudding; the intricate twistings and turnings of some layers and the unexpected, fantastic intrusion of others, all could not help but hold the eyes of both trained and untrained observers.

Though of great interest throughout its entire length, the section exposed where the cutting pierces the before-mentioned

ridge proved most interesting to me, and I shall therefore attempt its description somewhat in detail.

Beneath the eighteen inches or so of black soil at the surface, covering the top and slopes of the hill, is a yellow clay with a liberal admixture of sand, gravel, pebbles and boulders. Many of the boulders show striated and polished surfaces. Numerous small, angular fragments of limestone are everywhere present. In one of these was a number of specimens of *Nucula levata*, a lamellibranch which is found in the Maquoketa shales. There are great variations in the composition of this bed, but they occur in the form of irregular, curling drifts rather than of definite strata. This lack of any definite plan of structure combines with the great variety of materials found to give the yellow clay the heterogeneous look of a dumping ground.

At an average depth of about eight feet below the surface the yellow clay shades almost imperceptibly into a blue, which is so tenacious and compact as to require the use of the pick instead of the shovel in digging it. It offers an effectual barrier to water, which readily penetrates the loose, sandy clay above. It is everywhere broken up into polyhedral, usually cubical, fragments, whose angles project conspicuously in the face of the exposed section. This tough blue clay fills a trough under it, and rises in a broad curve above, determining the form of the hill; hence, it varies much in thickness. Below the highest point of the hill it is fully eighteen feet thick; three hundred feet either side, about one-fourth as much. Its structure is fairly uniform throughout. Boulders are very few and much decayed. Limestone fragments are found, as in the bed of yellow clay above, but there are also small fragments of wood and peat sparsely scattered through the whole bed, several fragments of both being found within eight feet of the surface of the ridge.

Next below this lenticular bed of clay is a bed of grayish-blue clay which has a nearly uniform thickness of about four feet. This bed curves downward at the center, its lowest point being about under the crest of the ridge. While the face of the section was fresh and unaffected by exposure, no distinction was noticed between this and the lenticular layer of clay above, but after repeated visits, the last one after the clay had been washed by the heavy rains and repeatedly frozen by night and thawed by day, a dim yet definite line of demarkation was visible.

Under the action of weathering this lower blue clay became distinguishable too, by reason of its smoothness of surface, from the upper blue clay, the face of which it has been already stated is covered with rough right-angled projections.

This difference would seem to be caused by a greater proportion of sand in the lower clay, which may be seen by close inspection to be the case.

Thus, while weathering dims the attractive colors, while it mutilates and must soon destroy the exposure, its immediate effect is to reveal stratification and texture that in the fresh surface of the glacial section are sometimes concealed.

This lower blue clay also shows a liberal number of angular fragments of limestone, one being observed which was a foot square and three inches thick. The entire bed, too, is found to be strongly impregnated with lime.

Fragments of wood are abundant throughout this four feet of sandy clay with its mixture of lime. Though the wood is fairly uniform in distribution in the different parts of the stratum, there seems to be no observable system in its distribution, no definite forest bed corresponding to the numerous instances given by McGee. This would seem to indicate that these woody fragments had been borne in from elsewhere rather than overwhelmed *in situ*.

The woody remains consist of stumps, trunks, branches and twigs. Such short roots are found only as remain attached to the stumps. The tree trunks are most frequently in a horizontal position, and in that case are flattened out of the cylindrical, thus showing the effects of pressure from above, since the vertical diameter is the shorter one. The maximum thickness of the trunks observed was eight inches, in a much decayed specimen. The length was uncertain. Preservation of the bark was observed in very few instances.

Nearly all the specimens found appear to belong to the same species. Its lines of growth are very close together, an indication that it grew slowly. It is apparently some soft wood.

All of the wood when found was saturated with water, which dried out very slowly on exposure to the air.

Though wood is found in both strata of the blue clay, fifty fragments may be found in the lower to one in the upper. Besides, the fragments in the lower bed are by far the larger.

It seems worthy of notice that the lower blue clay was deposited so evenly over the undulating sides as well as the

bottom of an irregular, basin-like depression. Taking this into account, and the difference in the occurrence of the wood of the two strata and their definite line of separation, one wonders whether the relation of the lenticular layer of clay may not be closer to the yellow clay above than to the blue below. The gradual blending of the upper into the middle stratum has been noticed, and the fact that wood occurs even in the transition between the two beds leads one to question whether it might not have been found up through the yellow clay were not that bed so loose of texture.

Next below the four feet of blue clay occurs a peaty bed that shows the same saucer-shaped depression as the clay above. On its upper surface, separating it from the clay, is a sheet of incoherent white sand which is fairly pure and shows irregular lines of sedimentation. Its thickness varies from nothing to six inches but it is fairly constant over most of the surface of the peat. The peaty formation has at the center a thickness of four feet, but it thins out and disappears within 300 feet in either direction. Its brown color makes it the best defined bed of the exposure, yet it is in structure far from uniform. The planes of stratification are frequently irregular, rising through the bed to the eastward. Such parts are clearly the results of sedimentation. Other layers are pure peat in regular and extensive sheets composed of closely compressed laminæ of moss as plain as if it was fresh from the botanist's press. These are certainly *in situ*.

Other vegetal remains than moss are wanting. Repeated and careful search discovered but one fragment of wood which was found in a sandy loam that underlies a small part of the peat. No roots are found except small ones, apparently those of the moss. Below the peat is a greenish colored clay, the lowest formation found. At the middle of the section it is invisible because below the bed of the cut, 300 feet either way it rises to a height of six or eight feet. It is a compact clay containing a considerable amount of sand and quartz, and other crystalline pebbles, but no limestone fragments, neither does this formation, nor the peat, show any impregnation with lime.

In the depression in this green glacial clay must have existed the swamp where the peat bogs formed during a great pause in the Ice Age. Upon this peat marsh came a flood of clay and sand bearing in its embrace the forest debris and limestone fragments. Next came a huge windrow of drift building a hill

over the ancient marsh; lastly, the mantle of yellow clay on which another soil has formed and now bears another growth of vegetation.

Thanks are due to Professor Calvin for kind encouragement and for the photographs of the section; to Professor Sardeson, of Minneapolis, for helpful suggestions, and to Engineer Wilkins, of the Chicago Great Western railroad, for use of the profile map.

EXPLANATION OF PLATE I.

Section of Pleistocene deposits as shown in the railway cut at Oelwein.

1. Thin layer of Iowan drift. Materials unoxidized, and boulders fresh and sound.

2. Kansan drift, oxidized and leached near the top. Many of the boulders in an advanced stage of decay. Grades downward into unoxidized blue till.

3. Sand boulders in Kansan drift. Upper ends are included in oxidized portion of this drift sheet; lower ends extend down into unoxidized portion.

4. Lower phase of Kansan drift which here shows physical characteristics resembling Number 7.

5. Thin layer of stratified sand, of Aftonian age, overlying peat.

6. Peat bed of Aftonian age.

7. Sub-Aftonian drift.

EVIDENCE OF A SUB-AFTONIAN TILL SHEET IN NORTHEASTERN IOWA.

BY S. W. BEYER.

Until very recently, geologists working in Iowa have been content to refer the various boulder clays represented in the state to two till sheets, a so called "upper" and "lower," separated in many places by the "forest beds" of McGee, or in other localities by gravels, often in conjunction with a vegetal horizon, the Aftonian of Chamberlin.

Early in the present year it was suspected by the assistant state geologist of Iowa that the lower till in central Iowa was not the equivalent of the lower drift sheet at Afton Junction. Later in the season Mr. Bain, in company with Prof. T. C. Chamberlin of the University of Chicago, revisited the Afton section, and what was at first a suspicion rapidly became a conviction. It was clear that the then recognized lower till of central and northeastern Iowa, extending southward into Kansas



and currently known as the Kansan, must be correlated with the upper till at Afton Junction. The Aftonian gravels were demonstrated to lie below the Kansan instead of above it, and the lower boulder clay at their type locality must be rechristened. Professor Chamberlin,* in an editorial on the series of glacial deposits in the Mississippi valley, designates the lower till at Afton by the term sub-Aftonian and suggests its probable equivalency with the Albertan of Dawson.

This fortunate discovery and happy recognition of a sub-Aftonian drift sheet in south central Iowa naturally suggested its probable presence in other portions of the state.

During the present autumn one and perhaps two sections in northeastern Iowa have been brought to light which afford additional evidence of a pre-Kansan ice sheet.

Oelwein Section.—The cut on the Chicago Great Western railway, east of the town of Oelwein, in southern Fayette county, exhibits the following series of glacial deposits:

- | | |
|---|-------------|
| 5. Boulder clay, rather dull-yellow in color; the upper portion is modified into a thin soil layer. Large boulders, mainly of the granitic type, are present, often resting on or partially imbedded in the deposits lower in the series. (Iowan) | 0-10 feet. |
| 4. Sand and gravel—not a continuous deposit; often shows water action expressed in parallel stratification lines and false bedding. The gravels are usually highly oxidized and fine textured. (Buchanan) | 0-2 feet. |
| 3. Till, usually bright-yellow above, graduating into a gray-blue when dry or a dull-blue when wet, below. This deposit is massive and exhibits a tendency to joint when exposed. Decayed granitic boulders are common. (Kansan) | 3-20 feet. |
| 2. (a) Sand, fine-white, well water-worn; often with a slight admixture of silt and clay. (Aftonian) | 0-6 inches. |
| (b) Vegetal layer and soil, from two to four inches of almost pure carbonaceous matter, with one to three feet highly charged with humus. The peaty layer often affords specimens of moss (<i>Hypnum</i>) perfectly preserved. (Aftonian) | 0-4 feet. |
| 1. Till, greenish-blue when wet or gray-blue with a greenish cast when dry. Greenstones and vein quartz pebbles predominate. (Sub-Aftonian or Albertan.) Exposed.... | 10 feet. |

The Oelwein hill trends northwest and southeast and is bilobed. The divisions will be referred to in the present paper as east and west lobes.

*Journal of Geology, vol. IV, No. 7, p. 873 *et seq.*, 1896.

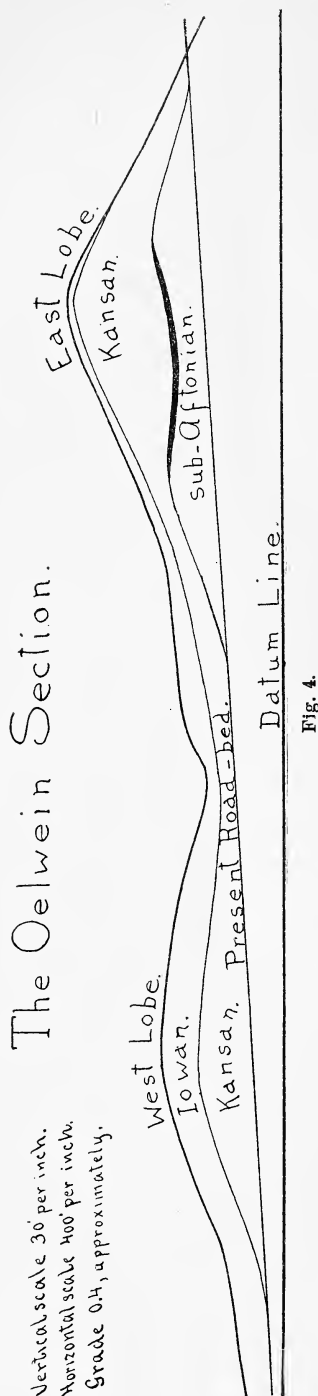


Fig. 4.

The Iowan reaches its maximum development near the summit of the west lobe, where it attains a thickness of some ten feet. The deposit thins eastward. At the crest of the east lobe little more than a foot of Iowan till is present, while at the extreme eastern limit of the cut Iowan boulders are partially imbedded in the Kansan. The till varies from a pale yellow to a moderately bright yellow color, and is not thoroughly leached nor oxidized. The Iowan shows a tendency to crumble on exposure, which is in striking contrast to the older drift sheets.

The line of separation between the Iowan and Kansan is not as well marked, in all cases, as could be desired but in most instances can be traced with some degree of confidence. In the west lobe a layer of sand sharply divides the two sheets for a distance of 100 feet, but when followed in either direction becomes much disarranged by the latter and in some places entirely loses its identity.

The Kansan is the predominant sheet in the cut and the topographic features of the region are faithfully depicted by the stiff boulder clay of this deposit. Its maximum exposure is in the east lobe, where it exhibits a thickness of twenty feet. The upper portion is oxidized to a bright yellow, sometimes brownish-yellow, often closely resembling the Iowan in color. The most distinctive feature in its separation from the latter are the character of the included boulders and the greater tenacity of the Kansan till. The Iowan pebbles and boulders are prevailingly of the granite type and

well preserved, while in the Kansan, greenstones are common and many of the granites are in an advanced state of decay. A granitic boulder more than a foot in diameter was noted which had been cleaved by the steam shovel without being loosened from its matrix. Sand boulders, lenses and wedges anomalously distributed through the oxidized portion and often extending into the upper portion of the blue till are common features. The wedges usually maintain a more or less vertical position with their apices pointing downward. The filling material in all cases very closely resembles the sand layers between the Iowan and Kansan. Oftentimes the position of the various sand forms is such as to suggest their common origin with the Buchanan. In many instances stratification lines are common. In the trough of the hill the lower portion of the Kansan contains lime concretions similar to the loess-kindchen and püppchen in great numbers. The lower three or four feet of the blue till contains wood fragments in considerable abundance in a state of almost perfect preservation. The physical properties of this portion of the Kansan are very similar to the sub-Aftonian.

The dividing line between the Kansan and sub-Aftonian is more sharply marked than between the upper two drift sheets. In the major portion of the section the sand layer and the peat bed are continuous, demonstrating the extreme gentleness of the advance of the Kansan ice. It seems remarkable that perhaps the greatest ice sheet that ever appeared in the Mississippi valley could override a peat-bog with no perceptible disarrangement of materials. The pertinence of Prof. T. C. Chamberlin's remark is apparent "that a glacier builds its own causeway." The surface of the sub-Aftonian is much more even than that of the Kansan; in fact it is not unlike that ascribed to our more modern peat-bogs. In certain places the upper part of the sub-Aftonian has been shifted and spheroidal masses of the peaty soil appear at the junction line imbedded in a Kansan matrix.

The drift sheet below the Kansan is represented by a massive gray-blue till with a marked greenish tone when unoxidized. The upper portion contains much humus and gives off a characteristic marsh-like odor when wet. The distinctive characters which serve to distinguish this boulder clay from the preceding are its color, the predominance of greenstone, and vein quartz pebbles and a less tendency to joint on

exposure. Granitic pebbles and boulders are, almost if not entirely, wanting. The pebbles in this as in the Kansan often exhibit polished, striated and faceted surfaces. The sub-Aftonian shows oxidation only where the superficial deposits are thin and the indications are that such oxidation took place after the deposition of the Kansan. At the extreme east end of the cut, beyond the peat-bed, there is an apparent exception to this rule. Blue till boulders of the Kansan are imbedded in an oxidized matrix of the basal drift sheet.

Albion Section.—Another section has come to the writer's notice during the past year which bears additional testimony to a drift sheet older than the Kansan. At the Albion mills on the Iowa river about ten miles northwest of Marshalltown, the following series of deposits may be observed:

- | | |
|--|----------|
| 6. Loess, stratified sands below..... | 20 feet. |
| 5. Till, yellow in some places apparently wanting and often represented by characteristic boulders, only. (Iowan)..... | 0-1 foot |
| 4. Gravel, some boulders four or five inches in diameter; granitic members often much decayed; limestone pebbles are common and boulders of Kansan till decorated with pebbles were noted. (Buchanan)..... | 2 feet. |
| 3. Till, the upper portion highly oxidized to a deep reddish-brown, unoxidized portion a gray-blue, exhibiting a jointed structure. (Kansan)..... | 4 feet. |
| 2. Sands and gravels, stratified and coarser below; oxidized in streaks, and bands approximately parallel to bedding planes; certain bands contain a considerable percentage of silt and clay. (Aftonian)..... | 10 feet. |
| 1. Till, blue. (Sub-Aftonian)..... | 10 feet. |

The Kansan at this point is more highly oxidized than at Oelwein, while the gravels between the Iowan and Kansan are very sharply defined.

The Aftonian does not present the iron-stained appearance usual to such deposits. Many of the pebbles and boulders are, however, in an advanced stage of decay.

EXPLANATION OF PLATES.

Plate II. The Oelwein Section.

1. Sub-Aftonian.
2. Aftonian.
3. Kansan, composed of an upper oxidized and a lower unoxidized portion.
5. Iowan.

Plate III. The Albion Section.

2. Stratified sands and gravels of the Aftonian.
3. Kansan till oxidized in part.
4. Buchanan, consisting of coarse gravel.
6. Loess, with stratified sands and silts below.





A PRE-KANSAN PEAT BED.

BY T. H. MACBRIDE.

In making an excavation through a low ridge just east of Oelwein, in Fayette county, the workmen of the Chicago Great Western railway have recently brought to light some very interesting superficial or quaternary deposits. As to the nature, age and significance of these deposits taken as a whole, our geologists are no doubt ready to give early and accurate account. It is for me in this brief paper to discuss, from the standpoint of the botanist, a single member of the series of strata thus fortunately brought to light.

By way of description it is sufficient to say that the railway cutting mentioned displays on the face of an almost vertical wall a succession of well-defined deposits in which have been recognized the two principal drift sheets with which Iowa is known to be more or less covered, the Iowan and the Kansan, and at least one more, prior to the Kansan and, of course, underlying it. These drift sheets or deposits are separated from one another in the Oelwein exposure, as elsewhere, by thin carbonaceous strata, the evidence of the vegetation which at one time covered the surface of the older deposit. At Oelwein one of these carbonaceous division sheets, and that the lowermost, is of remarkable prominence and thickness, and to this particular layer your attention is now invited.

Those who have had experience in such studies, and who have attempted to trace the limits of superficial deposits, know that contact lines are often exceedingly obscure; the strata are recognized by more or less abrupt change of color, or, at best, by simply a darkened trace; but here we have a stratum in some places nearly a foot in thickness, so purely organic as to form almost a brown coal, an unusually pure quality of peat, and so striking in appearance as to have won the attention of even the men of pick and shovel. The deposit is actually more dense than the clay or drift layers above and below, so that weathering brings it out as a distinct ledge to-day on the face

of the exposure. The stratum from the point of best exposure dips to the west, and, so far as I could observe, can be followed in that direction no more than twenty or thirty rods when it dips below the present level of the excavation. Eastwardly it thins out, and at length becomes only a trace, obscure, or vanishes entirely. For the greater part of the entire distance the structure and composition of the bed varies from rod to rod, but everywhere where the exposure is thickest the purity of the seam is greatest below. Indeed, in the most favorable case examined the purity of vegetable accumulation near the bottom of the formation is remarkable in the extreme, there being no admixture, so far as can be discovered, of any other substance whatsoever.

Upwards the materials are less pure, the amount of inorganic matter increasing until the seam blends above with the overlying blue clay or drift. It is a little surprising to find the lowest, that is, the oldest part of the bed, exhibiting organic objects in most perfect condition. The bottom of the seam is a compact mass of moss, compacted and pressed together no doubt, but absolutely untouched by putrefaction or decay, perfect in every leaf and fibre as any herbarium specimen in the world. Specimens you may examine show this perfectly. You may see the stem, the attachment of the leaves, the innovations, the form of each leaf, nay, the very areolation of leaf apex and base, quite as absolutely defined as in the case of any freshest specimen one may bring in now from any living turf or forest bed. For this reason we are able with much confidence to identify the species concerned although, so far, we have seen no smallest sign of capsule or fruit. So far, also, all the material seems to represent but a single species, a *Hypnum*, probably *Hypnum fluitans* Linn., a common moss which creeps out from shore or clings to floating objects, itself immersed or semi-floating in ponds, marshes or peat-bogs around the whole northern world.

Above the compacted moss which altogether makes up an inch or two of solid matter, lies a still more solid mass of vegetable detritus several inches thick. In this case the vegetation, whatever it was, appears to have undergone pretty thorough decomposition and disintegration before it was compacted. The microscope reveals simply cells and fragments of cells with considerable admixture of sharp, white sand, but nothing identifiable. This pulpy layer blends rather abruptly above

with a crude admixture of sand, mud and fragmentary vegetable detritus which, as said, becomes at length indistinguishable from the overlying drift.

In the very lowest portion of the (upper) drift, and often resting directly on the peat seam proper, are quantities of half-decomposed wood, not rotten wood at all, rather wood which has lost its lignin and of which only the cellulose basis remains, but showing all the original structure elements and features with perfection absolute. The wood seems identical with that of *Larix americana* Mx.

The facts before us would seem to warrant the following conclusions in reference to the state of affairs or conditions under which the peat bed was laid down: The *Hypnum fluitans*, free from all foreign matter of every kind, bespeaks a wide, clear, open marsh or peat-bog to which anything like muddy drainage from the surrounding regions never came. Here for a long period, probably centuries, the moss must have flourished undisturbed, but was at length completely submerged and drowned, probably by the closing of the drainage outlets. In the deeper water that succeeded flourished a different flora, probably a surface aquatic flora such as the *Lemnas*, filamentous algæ, *Anacharis*, possibly, whose dying fronds and filaments settled through other centuries to form at last the second layer of our peat bed seam. Over this, as has been stated, lies a mixture of organic and inorganic matter. Whether this was deposited *in situ* by another change in the depth of the water and local surface conditions or whether this represents the lowest part of the drift sheet as it came is difficult to say. In this particular layer there are evidences not a few of the presence of higher plants, monocotyledons chiefly. These may have been pushed in from other shallower parts of the same marsh. However this may be, the final catastrophe is not a matter of doubt. The whole region was slowly frozen up and at length whelmed by an icy deluge of frozen mud, fragments of swamp-loving trees wrenched and broken as they came, sand boulders, detritus of all the surrounding surface soils, whatever their variety, their flora or formation. Once this process complete, our peat bed remained hermetically sealed, unaffected, doubtless, by subsequent surface changes of any sort until stirred by the plowshare of the railway engineer. Considering the assumed great age of the deposit the state of preservation in which the plant remains occur is truly noteworthy. But then

we recall the notorious fact that peat-bogs and marshes, whether by the abundance of humic acid or from other causes, are pronouncedly aseptic. If moss, developed under such conditions, was finally buried at a low temperature and sealed up, its preservation is explained. But again, the wood fragments referred to are saturated with a solution of ferrous sulphate. The occurrence of this salt in this condition is a problem to which the attention of the chemist, rather than of the botanist, may be invited.

In closing, one other fact may be mentioned. Some years since well diggers of Washington county, in the town of Washington, brought up from great depth, some hundreds of feet, a perfectly preserved and uninjured cone. This I identified at the time as the fruit of *Larix americana*. If our determinations are therefore to be trusted, the Oelwein peat bed and the Washington cone represent the same horizon. As the only drift in Washington county is Kansan, the position of the Oelwein peat as pre-Kansan is to this extent rendered more certain.

SUMMARY OF DISCUSSION*.

BY PROF. S. CALVIN.

The discussion following the preceding papers on the Oelwein section was participated in by Calvin, Fink, Bain, Shimek, Beyer, Finch and others. The facts developed during the discussion may be summarized as follows:

A few years ago geologists were content to look upon the glacial period as a unit, and the drift mantle of Iowa was regarded as the effect of a single invasion and retreat of glacial ice. Some time ago, however, McGee demonstrated that in northeastern Iowa there are two distinct drift sheets separated by a soil horizon and forest bed which represent an interglacial period of considerable length. The two sheets of drift were then named respectively the lower and the upper till. Later two distinct drift sheets were recognized in Union county, near Afton Junction. They are separated by a soil bed and by

*A motion that Professor Calvin be requested to summarize this discussion was carried unanimously.

extensive deposits of water-laid gravels. It was at once assumed that the two drift sheets at Afton Junction were the upper and lower till of McGee. Within the past year or so Mr. Bain, of the Iowa Survey, studied the Afton deposits and became convinced that the till above the gravels and soil bed was equivalent to McGee's lower till, that the upper till was not present in that part of Iowa, and that the lower bed at Afton is distinct from any of the drift sheets recognized in northeastern Iowa. The locality was afterward visited in company with Professor Chamberlain and others and Bain's conclusions were fully confirmed. Here is a drift sheet older than McGee's lower till. In the meantime a lobe of drift, crossing the northern boundary of the state with a width reaching from Worth to Dickinson counties and narrowing toward its apex at Des Moines, was recognized as younger than the upper till of McGee. This youngest drift has been named Wisconsin by Chamberlin, McGee's upper till Chamberlin calls Iowan, and the lower till Kansan. The drift beneath the Aftonian soil and gravels is so far unnamed, but it is provisionally called sub-Aftonian. Mr. Leverett has recently shown that a bed of till occupying a small area in southeastern Iowa was deposited by glaciers coming from the northeast through Illinois. These glaciers spread a characteristic sheet of till over a large part of the state last named, and this drift sheet, which is younger than the Kansan and older than the Iowan, is called the Illinois.

There is therefore in Iowa a record of five ice invasions separated from each other by interglacial periods of considerable duration. The drift sheets corresponding to the several ice invasions are named in the order of age: 1, sub-Aftonian; 2, Kansan; 3, Illinois; 4, Iowan; 5, Wisconsin. The interglacial deposits between the first and second are called Aftonian. Respecting the length of the interglacial periods it may be shown that many of them were many times longer than the period that has elapsed since the retreat of the Wisconsin ice. The Oelwein cut to which reference is made in the papers under discussion is particularly interesting for the reason that it shows three of these drift sheets, the sub-Aftonian, Kansan and Iowan, in their normal relations. The first and second are separated by the peat bed which represents the Aftonian interglacial period. The second and third are separated by a zone of oxidation. The Iowan drift at the top of the cut is thin, but it contains boulders fresh as when they left the parent ledge.

The Kansan drift is thicker. It is deeply oxidized at the surface, and its granite boulders are so far decayed that the steam shovel has cut through individuals a foot or more in diameter without encountering as much resistance as is offered by the surrounding clay. The sub-Aftonian contains small pebbles of very hard crystalline rocks, many of the pebbles being of vein quartz, but there are few granites. Concerning the climate of the Aftonian interglacial period the wood and peat would indicate conditions similar to those that may exist in northern Maine.

Iowa is now classic ground for the study of Pleistocene deposits, and geologists the world over, if they would study these deposits to best advantage, must come to Iowa to do it.

ADDITIONAL OBSERVATIONS ON SURFACE DEPOSITS IN IOWA.

BY B. SHIMEK.

During the past summer the author made a series of observations, at the request of Prof. S. Calvin, upon the surface deposits of the northern part of the state, the results of which may be worthy of record.

Borings were made with a two and one-half inch auger attached to gas pipe, and in addition to this cuts along railways and wagon roads and exposures along creek and lake shores were examined. The chief observations were made at the following points:

a. At Clear Lake, in Cerro Gordo county, three borings were made in the timbered ridge east of the lake, as follows: One within five rods of the lake shore and two on the topmost part of the hill to the east.

b. At Forest City the following work was done:

1. Eleven borings were made due east from Forest City on the timbered ridge which extends north and south, parallel with Lime creek and just east of it, beginning at the top of the ridge north of the road, and thence at irregular intervals for 450 yards to the south. Nine of these borings were made at or near the summit of the ridge and two, one on each side, were made near the foot.

2. Two borings were made on a little plateau about one-half mile east of Lime creek, and notes on a well near by were taken.

3. Two borings were made on the timbered ridge south of Forest City, and several cuts along the Minneapolis & St. Louis railroad and at the gravel pit two miles south were examined.

4. Two borings were made between Forest City and Lake Edwards (in Hancock county), one near the top of a hill on which a few bur oak shrubs had gained a foothold, and one on lower ground. Observations were also made in cuts along wagon roads west of Forest City.

5. Well diggers were consulted at Forest City.

c. At Spirit Lake, in Dickinson county, exposures along the lake shores and cuts along railways and wagon roads were studied.

d. Near Granite, in Lyon county, five borings were made at various altitudes, about one mile west of Granite and south of the railroad, and observations were made in the railroad cuts between Granite and the Big Sioux river.

The results were fairly uniform and are here briefly summarized.

The succession of strata in the great majority of cases was as follows:

1. A fine black surface soil, sometimes mingled with fine sand, varying in thickness from six inches to two feet.

2. A compact yellowish layer of clay resembling loess, but sometimes with grains of sand and very small pebbles intermingled, and devoid of fossils. This is sometimes quite absent, but again reaches a thickness of nearly two feet.

3. A layer of yellow boulder-clay, with numerous boulders, these often several inches in diameter, occasionally much larger.

4. The boulders interfered with the borings, but where deeper sections could be observed it was found that this layer varied from five to fifteen feet in thickness.*

Where borings were made in low or flat grounds it was found that strata 1 and 2 averaged a little greater in thickness, and stratum 1 was rather more frequently mingled with sand.

The borings at Clear Lake and east of Forest City were made in the timber. In all these stratum 1 was greater in thickness and was mostly made up of finer material.

* Beneath this layer at Forest City occur pockets of sand, underneath which is a blue boulder-clay of great thickness, said by the well diggers at Forest City to vary from sixty to 100 feet in that vicinity.

The yellow boulder-clay—stratum number 3—has boulders scattered throughout its thickness, but, as a rule, on slopes and near the tops of hills these are much more abundant in the upper part, immediately under strata 1 and 2.

This is strikingly shown in some of the cuts and exposures at Forest City, Spirit Lake and Granite. It appears as though this stratum had at sometime been much thicker upon the hills, forming their barren surface immediately after the recession of the glacial sheet. By the action of winds and water the finer material at the surface was sifted out and carried away before the hills were covered with vegetation, the heavier boulders being but little disturbed, excepting as they were undermined. As a result the hills were cut down and the boulders were brought closer together at the surface. Their accumulation retarded the surface disturbances and the vegetation peculiar to barren grounds was enabled to gain a foothold. Finer material, brought hither by the winds,* was retained by this vegetation and a new surface soil was formed—the stratum number 2—of which a vegetation more abundant then took possession. This retained still finer material, mingling with it its own decomposed substance, and the present surface soil—stratum number 1—was gradually formed. It may here be noted that the finest part of the material from stratum number 3 seems to be in all respects like our loess.

The conditions which probably prevailed before the formation of strata 1 and 2 are still illustrated by comparatively barren prairie hills west of Forest City and in the vicinity of Granite, where stratum number 3, or mere indications of number 2, form the surface, whose vegetation, as incidentally noted in the following paper, is quite different from that of the more fertile surrounding prairie.

The occurrence of the scrub bur oak groves on some of these hills is interesting. The plants are chiefly shrubs, seldom more than five feet in height, and usually not closely crowded, and they seem to prosper best on the leeward side of the hills and in ravines.

This is strikingly shown near Granite. The observer may stand on one of the hills west of Granite, and looking to the

* Even such small pebbles as those which occur in stratum number 2 could be rolled a considerable distance by winds. The author saw, last spring, an accumulation of sand on a hill in the southern part of West Cedar Rapids which completely covered a fence fully five feet high. In the deposit were small pebbles, yet the wind had clearly formed the stratum full five feet in thickness since the fence had been built. When the workmen were removing a portion of the deposit for the purpose of opening a road it was observed (by the author) that the sand was quite regularly stratified, the numerous lines following the surface configuration.

south and southwest, and also to the west and northwest across the Big Sioux river into South Dakota, he may locate almost every one of the little ravines with which the slopes bordering the deeper ravines are scarred, by the dark lines of bur oaks. The number of these smaller ravines which are tributary to some larger one is often so great that a pinnate arrangement of these dark lines results. The shrubs in that vicinity are found generally on the northern and eastern slopes, where they are best protected from the prevailing strong southwesterly winds, and the surface soil on these slopes is much deeper and finer, and is also covered with a richer flora. On the other hand, many of the western and southern slopes are strewn with granite boulders, and a scant vegetation barely covers the surface, which almost lacks a finer soil—stratum number 3 forming the surface. These groves would probably have formed nuclei of greater forests had not man interfered, for, in the northern part of the state at least, the bur oak seems to be the pioneer among trees, being followed by the red oak, which now forms the greater part of our northern and northwestern upland groves.

The conclusion seems warranted that while soil largely determines the character of a flora, the converse is equally true that the flora will in time affect the character of the soil, and that the influence of vegetation upon superficial geological changes should not at least be disregarded.

The conclusions drawn from the observations here briefly recorded are the following:

1. The boulder-bearing stratum marked 3 formed the surface at one time throughout the region studied. Before vegetation had taken possession of it the finer material was sifted from the upper part of the stratum, concentrating the boulders.

2. Subsequently a comparatively scant vegetation took possession, making possible the retention of a somewhat coarse soil,—stratum 2.

3. A richer vegetation then followed, enabling the retention of a finer soil,—stratum 1.

4. Forests, where occurring, followed next in order, being ushered in in the manner suggested by the present bur oak scrub-tracts.

5. The agency concerned chiefly in accumulating the finer surface soils was wind, the material being retained in place by vegetation.

6. The action was probably not simultaneous over the entire area, the fine material removed from the most barren parts being deposited in places already prepared for its retention.

THE FLORA OF THE SIOUX QUARTZITE IN IOWA.

BY B. SHIMEK.

The Sioux quartzite is exposed in this state only in the extreme northwestern corner of Lyon county. Other and greater exposures however are found in the adjacent parts of South Dakota.

The chief exposure on the Iowa side is located only a few rods south of the state line and about one and three-quarters miles east of the Big Sioux river.

It occupies a depression in the rolling prairie, which is bordered by hills on the north, east and south, and slopes gradually to the Big Sioux bottoms to the west. It is best seen at and near the junction of two streamlets, one coming from the east and the other from the south, the course of the resulting stream being westward.

At the time that the observations herein recorded were made (August 4 and 6, 1896), these streamlets were almost dry, there being only a few disconnected pools of water.

The greater portion of the exposure is horizontal, vertical ledges not exceeding six feet in thickness being found only along the streamlets for a few rods above their juncture.

The exposure is in part barely disguised by a scant surface soil upon which, and upon the bare rock, flourishes a flora in some respects unique, and strikingly different from that of the surrounding prairie, a fact already noted by Prof. J. C. Arthur, who in the "Contributions to the Flora of Iowa," No. VI,* says: "The extreme northwestern corner (of Iowa) is geologically and botanically very unlike the rest of the state."

The list of plants herein given is undoubtedly far from complete, being the result of a rather hasty survey. It shows a flora which is sufficiently unique, however, to be of interest to the student of plant distribution.

* Proc. Davenport Acad. Sci., vol. IV., p. 73.

The plants in the first list seemed to be restricted to the exposure and have not been collected anywhere else in the northwestern part of the state by the author, nor have they been reported from that section excepting from the immediate locality under consideration. They are:*

Talinum teretifolium Pursh. Abundant. Also reported from Woodbury county.

Hosackia purshiana Benth. Abundant. In fruit. Also reported from Henry and Woodbury counties.

Opuntia fragilis Nutt. Common. A few fruits were found.

Aphyllon ludovicianum Gray. Not common. Not heretofore reported from the state.

Isanthus cœruleus Mx. Not common. A stunted unbranched form. The species occurs in Henry, Muscatine and Johnson counties, in the eastern part of the state.

Polygonum tenue Mx. Common. Also reported from Linn and Muscatine counties.

Buchloe dactyloides Eng. Staminate plants were not rare.

Woodsia scopulina Eaton. Rather common. Found in crevices of the rock. This has not been reported from the state. The specimens, which were collected with fruit in all stages of development, are typical.

Selaginella rupestris Spring. Common. The species is also reported from Muscatine, Winneshiek and Benton counties.

Asterella hemisphaerica Beauv. Not common. Abundant in the eastern part of the state. With the exception of the liverwort *Asterella* all of the species in the list are distinctly dry and barren ground plants, and even the exception commonly occurs in places which are wet only during a short period each year. It will be noticed also that the species belong largely to the flora of the dry western and northwestern plains.

The second list includes plants which occur on this exposure, but are also found upon dry, sandy, or gravelly hillsides on the prairies throughout the northwestern part of the state, and also in isolated localities in other parts of the state upon sandy, barren tracts. These also belong to the western flora. They are:

Astragalus lotiflorus Hook. Not common. Found also on the barren hills near Granite. Heretofore reported only from Fremont county.

*The nomenclature here employed, excepting that of the lichens, is, like that of most of the Iowa lists heretofore published, that of Gray's Manual. Without regard to the merits of the nomenclature controversy, this will make the notes more convenient for comparisons.

Liatris punctata Hook. Not rare.

Chrysopsis villosa Nutt. Rather common. Not reported from Iowa.

Aster oblongifolius Nutt. Not rare.

Aster ptarmicoides T. and G. Not common.

Artemisia canadensis Mx. Not common.

Artemisia frigida Willd. Not common. Not reported from any other part of the state.

Lygodesmia juncea Don. Not common.

Cuscuta arvensis Beyr. Common, chiefly on the two species of *Artemisia* mentioned.

Pentstemon gracilis Nutt. In fruit. Not common. This is the first report of its occurrence in the state.

Pentstemon grandiflorus Nutt. Rare on the exposure, but very common on the barren hills west of Granite.

Verbena angustifolia Mx. Not common.

Plantago patagonica Jacq., var. *gnaphaloides* Gray. Common. Reported from several counties in the western and southwestern part of the state.

Oxybaphus hirsutus Sweet. Not common.

Salsola kali L., var. *tragus* (L.) Moq. A dwarf form not exceeding eight inches in height, with mostly simple stems, was quite common.

Bouteloua oligostachya Torr. Common.

Bouteloua hirsuta Lag. Not rare. Both of these species are quite common near Granite, and also near Rock Rapids, in Lyon county.

Carex stenophylla Wahl.* Not uncommon. A rare species, heretofore found in this state only in Emmet county.

Placodium vitellinum (Ehrh.) Naeg. and Hepp.† Not uncommon.

Placodium vitellinum var. *aurellum* Ach. Rather rare.

Placodium elegans (Link) D. C. Rare.

Placodium cerinum (Hedw.) Naeg. and Hepp. (?) Not common.

Lecanora cinerea (L.) Sommerf. Not common.

Lecanora rubina (Vill.) Ach. Quite common.

Lecanora muralis (Schreb.) Schær., var. *saxicola* Schær. Quite common.

Rinodina oreina (Ach.) Mass. Very common.

* The species of *Carex*, mentioned in this paper, were partly identified or verified by Prof. R. I. Cratty.

† The lichens were identified or verified by Prof. Bruce Fink.

Parmelia conspersa (Ehrh.) Ach. The most common lichen on the exposure, covering large areas of rock.

Physia caesia (Hoffm.) Myl. Not common.

Omphalaria ———. An undescribed species found in Iowa, Minnesota and Nebraska. Not common.

Pertusaria ——— sp. (?) Not common.

Endocarpon miniatum (L.) Schær. Rare. Probably a variety.

The lichen flora of the exposure, very conspicuous by its abundance and variety, is an exceedingly interesting one. The rock in many places is fairly covered with these persistent forms, and the species are, for the most part, identical with those which occur on surface granite boulders in the northern or northeastern part of the state.

In addition to the species given in the preceding list, there are several which may be found almost anywhere on the prairies, and which readily adapt themselves to new surroundings, yet are properly dry ground species. They are:

Delphinium azureum Mx. Not common.

Psoralea argophylla Pursh. Not rare.

Psoralea esculenta Pursh. Rather rare.

Castilleja sessiliflora Pursh. Rare.

Hedeoma pulegioides Pers. Very common.

Juncus tenuis Willd. Common.

Carex cephalophora Muhl. Not common.

Carex straminea Willd., var. *brevior* Dewey. Quite common.

Carex straminea Willd., var. Not common.

Andropogon scoparius Mx.* Common.

Stipa spartea Trin. Common.

Muhlenbergia glomerata Trin. Not common.

Sporobolus cuspidatus Torr. Common.

Calamagrostis canadensis Beauv. Common.

Calamagrostis longifolia Hook. Common.

This report would be incomplete without a list of the species which were found along the edges of the pools left by the streamlets. They do not properly belong to the flora of the rock-exposure, but their presence is of interest, especially as some of them were observed nowhere else in Lyon county. They are:

Rotala ramosior Koehne. Not common. Known heretofore only from Benton and Henry counties.

*For the identification of some of these grasses thanks are due to Prof. L. H. Pammel.

Ammannia coccinea Rottb. Not common. Reported only from Story county.

Veronica anagallis L. Not common.

Juncus nodosus L., var. *megacephalus* Torr. Not rare.

Beckmannia erucaeformis Host., var. *uniflora* Scrib. Quite common near two of the pools, but not found by the author at any other point. It is also reported from Story (introduced) and Plymouth counties.

As has been noted, the plants which constitute this flora are for the most part inhabitants of dry and more or less barren regions. The flora may be duplicated in part in several barren isolated spots in other portions of the state. One of these is found in Muscatine county, and many of its interesting forms have already been reported by Mr. Fred Reppert; another is in Dubuque county; and still others are mentioned by Prof. L. H. Pammel.*

It is probably the remnant of a flora which once covered the greater part of the north half of the state. It is closer in its relation to the western than to the eastern flora, and its evolution probably took place to the west and southwest beyond the limits of the glacial sheet.

The recession of the glaciers left a barren surface, for the most part covered with sand and boulders, and seamed and scarred by the vast sea of ice. The depressions were occupied by water, and upon the bleak hills this flora slowly established itself. But its own presence gradually caused an accumulation of finer surface soil, and other plants, more vigorous and rapid growers, took possession of the now fertile spots. The fertile area thus increased until only a remnant of the original flora was left in the few spots which presented conditions most nearly like those which prevailed soon after the disappearance of the ice sheet.

The distribution of the lichen flora probably differed from that of the higher plants. The wonderful vitality of the lichens, especially as illustrated by their habits far to the north, admits of the belief that they were able to exist even through the glacial period. It is probable that the ledges of the Sioux quartzite, then much more prominent, were covered with lichens even before the glacial epoch, and that the same force which ground out the boulders from the solid rock carried fragments of lichens out over the state eastward and southward. It is

*Proc. Iowa Acad. Sci., vol. III, p. 106.

probable that the glaciers advanced and receded with the changes of seasons, and with each recession of the ice the lichens were given a new lease of life. Thus while the higher plants from the east and the west met on the barren prairies of Iowa, those from the west at first predominating, and while their advance was probably respectively from the southeast and southwest, the lichens of the rocky ledges and boulders came to us from the north and represent the oldest flora in the state.

NOTES ON AQUATIC PLANTS FROM NORTHERN IOWA.

BY B. SHIMEK.

The aquatic flora of northern and northwestern Iowa is of great interest, and it deserves especial attention because the occupancy of that part of the state by agricultural man is rapidly transforming the "Thousand Lake Region of Iowa," as the early settlers called it, into thousands of pastures, flax fields and wheat fields.

The lakes and ponds are being drained either artificially or by the changes in surface conditions, and while it is probable that the aquatic flora will persist in the larger lakes for a long time, it will certainly be restricted; it is, in fact, already restricted, and if these large lakes change as rapidly as Clear lake, Spirit lake and Lake Okoboji (to say nothing of smaller ones) have in the past few years, Iowa will soon know no lakes. It is important, therefore, that the history of the aquatic plants of the northern part of the state be as complete as possible, and that specimens of these plants be preserved for future reference.

Various scattered notes on this flora have been published, but thus far only one paper specially devoted to it has appeared. Early in the year Mr. R. I. Cratty published* an admirable paper on the aquatic flowering plants of Iowa, and these notes are practically merely supplementary to that paper. A part of the field work at Spirit lake and Lake Okoboji, the results of which are here given, was made in company with Mr. Cratty, and his experience and enthusiasm added much to the interest and the value of the work.

*Bulletin Lab. of Nat. His., State Univ. of Iowa, vol. III, No. 4.

The collections on which the notes are based are deposited in the herbarium of the State University of Iowa. To avoid repetition the dates of collecting are here given for the several localities:

Mason City—July 6–9, 1896.

Clear Lake—July 10th–13th.

Forest City, Lake Edwards and the northern part of Hancock county*—July 17th–21st.

Spirit and the Okoboji lakes—July 30th–August 3d.

Rock Rapids and Granite—August 3d–7th.

The following is an annotated list of the species which were collected:†

Nymphaea reniformis D. C. Found in Clear Lake and in the Big Sioux river near Granite. These localities have not been noted heretofore.

Nuphar advena Ait. f. Additional localities: Mason City, Forest City, Spirit Lake.

Myriophyllum spicatum L. Additional localities: Lake Okoboji, common. Mostly in bud. Clear Lake, very common. All in bud. Growing in two to four feet of water.

Myriophyllum heterophyllum Mx. Clear Lake. Rather more common than the preceding. Forest City, not common in Lime creek.

Utricularia vulgaris L. Rather rare at Forest City, in Lime creek.

Ceratophyllum demersum L. Very common in West Okoboji lake, forming beautiful branching tufts in water three to six feet deep.

Elodea canadensis Mx. Very common in Lake Edwards and in the Okoboji lakes. New localities: Rock Rapids, in Rock river. Not common. Clear Lake, very common.

Vallisneria spiralis L. This interesting species was very common in Clear Lake, especially at the west end, but none were found in flower.

In Spirit Lake, along the western shore, small specimens of pistillate plants were collected in shallow water. These grew on a gravelly bottom.

A splendid lot of specimens were collected at the lower end of East Okoboji lake, near its juncture with the west lake. The leaves ranged in length from one to at least four feet, and

* Partly made in September, 1895.

† For convenience in making comparisons the nomenclature is largely that of Mr. Cratty's paper.

hundreds of pistillate flowers in all stages of development were found. A fine series of the staminate flowers were collected. These, so far as observed, were restricted to a small area, seemingly not more than a square yard in extent, in which staminate flowers only were found. These were at a depth of about two feet, growing like the others on a mud bottom.

Heteranthera graminea Vahl. This species is distributed throughout the state. It was common at Mason City, Forest City, Lake Edwards, Lake Okoboji, Rock Rapids, in Rock river, and in the Big Sioux river near Granite.

Spirodela polyrrhiza Schleid. Common at Forest City in Lime creek.

Lemna trisulca L. Very common in Lake Edwards, and also found at Forest City.

Lemna minor L. Abundant in the Big Sioux river near Granite, and in Rock river at Rock Rapids.

Potamogeton natans L. Not rare in the west end of Clear lake. Some were in fruit, others in flower. Specimens collected in Spirit lake were finely fruited.

Potamogeton nuttallii Cham. and Schl. This rare species, which has hitherto been reported in Iowa only from Muscatine county, was found in a small pond in northern Hancock county south of Forest City near the intersection of the Minneapolis & St. Louis railroad and the Burlington, Cedar Rapids & Northern railroad. It was mostly in fruit. A month later Mr. Cratty collected it in fine fruit at the same place.

Potamogeton spirillus Fuck. Found with the preceding. The species had been reported from Muscatine and Poweshiek counties. It is rare.

Potamogeton lonchites Fuck. This was common, in flower, in the Big Sioux near Granite, and in Rock river at Rock Rapids. The submersed leaves were abundant.

Potamogeton amplifolius Fuck. Common in the west end of Clear lake, mostly in flower. A form with narrower, nearly green leaves was not rare. Common and well fruited in Lake Okoboji and Spirit lake. Rare in Rock river at Rock Rapids.

Potamogeton prelongus Wnef. Rather common in Clear lake. Fine specimens, 8 or 10 feet long, were abundant in deep water. Rare in East Okoboji lake. No flowers or fruit were collected.

Potamogeton perfoliatus L., var. *richardsonii* A. Benner. Common in flower in the west end of Clear lake. Very abundant in Okoboji lakes in flower and fruit. A form found in Spirit

lake, growing on gravelly bottom along the west shore, approaches the type in the character of the leaves.

Potamogeton zosteræfolius Schum. Common in Clear lake, in flower. Also common in Lake Edwards. Common in the Okoboji lakes, some finely fruited, but most of them in flower. Not common in Rock river at Rock Rapids.

Potamogeton foliosus Raf. Abundant in Lime creek near Forest City, mostly in flower. Mr. Cratty found it a month later in fine fruit.

Potamogeton major (Fries) Morong. Common in Clear lake, some in fruit, but most of it in flower. Very common in the Okoboji lakes at their juncture. In good fruit, but flowering specimens were common.

Potamogeton pussillus L. Rare in Clear lake at west end. Some in fruit, others flowering. Not common in East Okoboji lake near its northern extremity. The glands at the base of the leaf are well shown in most of the specimens.

Potamogeton pectinatus L. Common, mostly in flower, in Clear lake. The specimens growing on sandy bottom at the east end of the lake were slender and few-leaved. Also common in Lake Edwards. Very fine and in excellent fruit in East Lake Okoboji. Rare in Rock river near Rock Rapids.

Nais flexilis (Willd) R. & S. Very common in rather shallow water in Lake Edwards, Clear lake and Spirit. Growing on sandy or mud bottoms.

Zannichellia palustris L. Quite common and in fruit in shallow water on gravelly bottom along the west shore of Spirit lake. Much finer specimens were found in East Okoboji lake in somewhat deeper water. The leaves were in excellent condition for collecting, and many species of aquatic plants which seldom fruit were found in splendid condition. The following algæ, identified by Miss Lucy M. Cavanagh were also collected:

Chætophora pisiformis (Roth) Ag. Common in West Lake Okoboji.

Chætophora monolifera Kg. Common on *Cladophora* in Clear lake. New to the state.

Cladophora obigoclona Kg. Common in Clear lake.

Cladophora glomerata Kg. var. Common in West Lake Okoboji.

Cladophora fracta Kg. Common in West Lake Okoboji.

Cladophora fracta var. *gossypina* Kg.(?) Common in West Lake Okoboji.

Cladophora fracta Kg. var. In West Lake Okoboji.

Hydrodictyon utriculatum. Very common in Lime creek, at Forest City.

SPERMATOPHYTES OF THE FLORA OF FAYETTE, IOWA.

BRUCE FINK.

INTRODUCTION.

A considerable amount of work has been done on the flora of the vicinity of Fayette since the early settlement, and during the last five years the writer has explored the region thoroughly. Nearly 200 of the plants of this list have been carefully compared by the writer and other persons at the herbaria of the University of Minnesota and Harvard university. I have also had the aid of specialists on five difficult genera, and altogether the list of a few more than 700 species and varieties has been carefully worked out.

The early work was done by Dr. C. C. Parker who, previous to 1876, had collected and preserved nearly 500 specimens of our herbaceous plants. Dr. Parker's herbarium contains twenty-eight plants not found by the writer, which are listed. They may be known, as he is given credit for the collecting. I am also indebted to him for the use of his herbarium in preparing this record, and for valuable aid in finding several rare plants.

As to territory covered, the list is approximately complete for the region within five miles of Fayette. A few plants are included which were collected ten or fifteen miles away, but the work is doubtless quite incomplete for some portions of Fayette county. This region furnishes a good field for the study of the higher plants, as the topographical features are quite varied. Prairies, woods, rivers, springs, marshes, ponds, hills and limestone ledges all abound. The woods, even after so much clearing has been done, are a more inviting field for study than the limited amount of unbroken prairie. Twenty years ago the prairie grasses and sedges were surely much more abundant than now, but unfortunately they were not

studied till quite recently, after the prairies had been largely brought under cultivation. This accounts for the small number of grasses and sedges listed, after I have collected them as carefully as other genera—except the genus *Carex*, which needs more study.

I wish to express my thanks to Dr. B. L. Robinson, and to Prof. Conway MacMillan, for the use of the herbaria mentioned above, in comparing plants. The late Mr. M. S. Bebb named the species of *Salix*, Mr. M. L. Fernald those of *Carex* (except four species collected by Mr. A. S. Skinner and Miss Ona M. Rounds in 1896, which were determined by Mr. R. I. Cratty), Prof. C. S. Sargent those of *Quercus*, and Mr. R. I. Cratty those of *Sagittaria* and *Potamogeton*. Mr. A. A. Heller and Mr. J. W. Blankinship also aided in the determination of a number of species. To all of these gentlemen I am greatly obliged for the aid freely given.

That the unrest in botanical synonymy is to continue for some time is certain, if, indeed, all features of it can be permanently settled. I have used the arrangement and synonymy of Gray's Manual, sixth edition, which doubtless is not to stand long without radical change. The work has grown up under this system, and it will serve its purpose so that this record can be used in the future study of this vicinity or a somewhat larger one. Furthermore, this manual has commonly been used in Iowa in making general lists.

The plants herein recorded will be found in the herbaria of the persons who are credited with the collections. The herbarium of the Upper Iowa university contains nearly all the species also, and the writer has collected 640 of them for the United States National Herbarium. These last were delivered in 1894.

Nearly all the species listed were collected by the writer. Other collectors are given credit for the plants collected by them. Besides, Dr. C. C. Parker, Mr. J. R. Gardner, Mr. A. S. Skinner, Mr. R. B. Wylie, Miss Gam E. Rounds, Miss Ona M. Rounds, Miss Etna Burette and Mr. W. F. Baker have each added to the work by their collecting. I am under obligations to all of them for this help.

Several species are herein reported for the first time in Iowa, as is indicated with the names of these plants. Further study of this vicinity will bring out new information regarding the families here treated. If this list shall aid in such investiga-

tion or prove helpful to the botanists of other parts of Iowa, I shall feel well rewarded for the many days spent in collecting and studying the plants and in the final preparation of this paper.

LIST OF SPECIES.

RANUNCULACEÆ.

- Clematis virginiana* L. Banks and low thickets, infrequent.
Anemone patens L., var. *nuttalliana* Gray. High prairies, common.
A. caroliniana Walt. Prairies, rare.
A. cylindrica Gray. Woods, frequent.
A. pennsylvanica L. Low prairies, common.
A. nemerosa L. Dry woods, common.
Hepatica acutiloba D. C. Woods, common. *H. triloba* Chaix is frequently reported here, but does not occur.
Anemonella thalictroides Spach. Woods, abundant.
Thalictrum dioicum L. Woods, common.
T. purpurascens L. Low prairies, infrequent.
Ranunculus circinatus Sibth. Ponds, probably rare. The leaves are sessile or nearly so, have stipules and are more rigid than those of the next.
R. aquatilis L., var. *trichophyllus* Gray. Ponds, infrequent. Coll. Mr. R. B. Wylie.
R. multifidus Pursh. Ponds, rare.
R. rhomboidens Goldie. Prairies, frequent.
R. abortivus L. Low open woods, common.
R. fascicularis Muhl. High prairies and open woods. Common.
R. septentrionalis Poir. Borders of swamps; infrequent.
R. hispidus Hook. Woods, apparently frequent; but probably *R. repens* L. or *R. pennsylvanicus* L. occurs and has been confused with the above. Not before reported in Iowa.
Isopyrum biternatum Torr. and Gray. Low woods, frequent.
Caltha palustris L. Wet ground, infrequent.
Aquilegia canadensis L. Along bluffs, frequent.
Delphinium exaltatum Ait. Low prairies, rare.
D. ajacis L. Sparingly escaped.
Actæa spicata L. var. *rubra* Ait. Woods, frequent.
A. alba Bigel. Woods along bluffs, rare.
Hydrastis canadensis L. Rich woods, rare.

MENISPERMACEÆ.

Menispermum canadense L. Along sandy river banks, rare.

BERBERIDACEÆ.

Caulophyllum thalictroides Michx. Woods, frequent.

Podophyllum peltatum L. Woods, common.

NYMPHÆACEÆ.

Nymphaea odorata Ait. Ponds, infrequent.

Nuphar advena Ait. Ponds, infrequent.

PAPAVERACEÆ.

Sanguinaria canadensis L. Woods, common.

FUMARIACEÆ.

Dicentra cucullaria Torr. Woods, common.

D. canadensis Gray. Woods, rare. Fruit collected here in 1894 by Miss Etna Burette. Only reported elsewhere in Iowa by Mr. E. W. D. Holway, at Decorah. Single spot a few rods square known here.

CRUCIFERÆ.

Dentaria laciniata Muhl. Woods, common.

Cardamine rhomboidea D. C. Wet ground, common.

C. hirsuta L. Wet ground, frequent.

Arabis laevigata Poir. Wooded hillsides, rare. Leaves usually entire except those at the base.

A. canadensis L. Open woods, frequent.

A. dentata Torr. and Gray. River banks, frequent.

Draba caroliniana Walt. Waste ground, infrequent.

D. caroliniana Walt., var. *micrantha* Gray. Waste ground, common.

Nasturtium officinale R. Br. Streams and springs, rather rare.

N. palustre D. C. Wet ground, frequent.

N. armoracia Fries. Escaped, rare.

Hesperis matronalis L. Escaped, rare.

Erysimum cheiranthoides L. Low ground, infrequent.

Sisymbrium canescens Nutt. A single spot known here in a sandy opening.

S. officinale Scop. Waste ground, common.

Thelypodium pinnatifidum Watson. River banks, rare.

Brassica nigra Koch. Waste ground, common.

Capsella bursa-pastoris Mönch. Waste ground, common.

Lepidium intermedium Gray. Waste ground, common.

CAPPARIDACEÆ.

Polanisia graveolens Raf. (?) Probably *P. trachyspermum* Torr. and Gray. Sandy ground, rare.

CISTACEÆ.

Helianthemum canadense Michx. Dry hills, infrequent.

Lechea minor L. Dry prairies, infrequent.

VIOLACEÆ.

Viola pedata L. Prairies and open woods, common.

V. pedatifida Don. Prairies, frequent.

V. palmata C., var. *cucullata* Gray. Low prairies, common.

V. sagittata Ait. Found only in the first railroad cut two miles south of Fayette.

V. blanda Willd. Moist prairies, rare. Mr. W. F. Baker, coll.

V. pubescens Ait. Woods, common.

V. tricolor L. Rarely escaped.

CARYOPHYLLACEÆ.

Saponaria officinalis L. Frequently escaped.

Silene stellata Ait. Woods, frequent.

S. nivea Oth. Low prairies and woods, frequent.

S. antirrhina L. Dry ground, frequent.

S. noctiflora L. Rarely escaped.

Lychnis githago Lam. In fields, rare.

Arenaria michauxii Hook. Dry prairies, infrequent.

A. lateriflora L. Low prairies, rather infrequent.

Stellaria media Smith. Low woods, infrequent.

S. longifolia Muhl. Borders of swamps, rare.

Cerastium vulgatum L. Dr. C. C. Parker, coll. Marked in herb. *C. viscosum* L.

C. arvense L., var. *oblongifolium* Britt and Hall. Dry woods, rare.

PORTULACACEÆ.

Portulaca oleracea L. Cultivated and waste ground, abundant.

Claytonia virginica L. Moist woods, common.

HYPERICACEÆ.

Hypericum ascyron L. Banks of streams, infrequent.

H. maculatum Walt. Wet prairies, frequent.

H. canadense L., var. *majus* Gray. Banks and low prairies, common.

Elodes campanulata Pursh. Borders of swamps, infrequent.

MALVACEÆ.

- Malva rotundifolia* L. About yards, frequent.
M. sylvestris L. About yards, rare. Also collected by Dr. C. C. Parker.
Napæa dioca L. Low sandy soil, very rare.
Abutilon avicennæ Gært. Waste ground, frequent.
Hibiscus trionum L. Waste ground, rare.

TILIACEÆ.

- Tilia americana* L. Woods, frequent.

LINACEÆ.

- Linum sulcatum* Riddell. Dry prairies, frequent.
L. usitatissimum L. Occasionally escaped.

GERANIACEÆ.

- Geranium maculatum* L. Woods, common.
G. carolinianum L. Waste ground; only two plants have been collected here.
Oxalis violacea L. Waste ground, etc., abundant.
O. corniculata L., var. *stricta* Sav. Woods and waste ground, common.
Impatiens pallida Nutt. Wet shady places, frequent.
I. fulva Nutt. With the last, frequent.

FUTACEÆ.

- Xanthoxylum americanum* Mill. Woods, common.

CELASTRACEÆ.

- Calastrus scandens* L. Wooded river banks, infrequent.
Euonymus atropurpureus Jacq. Woods, rare.

RHAMNACEÆ.

- Ceanothus americanus* L. Open woods, common.

VITACEÆ.

- Vitis riparia* Michx. River banks and low woods, common.
Ampelopsis quinquefolia Michx. Woods, infrequent.

SAPINDACEÆ.

- Acer saccharinum* Wang. Woods, common.
A. saccharinum Wang., var. *nigrum* Torr. and Gray. A single tree known in low woods.
A. dasycarpum Ehrh. River banks, infrequent.
Negundo aceroides Mœnch. Low woods, infrequent.
Staphylea trifolia L. Woods, infrequent.

ANACARDIACEÆ.

Rhus typhina L. Common five miles east of Fayette. Probably rare further west in Iowa.

R. glabra L. Woods, common. The form with laciniate leaves is represented by a specimen (herb. Dr. C. C. Parker) marked *var. laciniata*.

R. toxicodendron L. Rocky river banks, common. The climbing form, *R. radicans* L., has been noticed but once.

POLYGALACEÆ.

Polygala senega L. Woods, common.

P. incarnata L. Dry ground, rare. Dr. C. C. Parker, coll.

P. sanguinea L. Prairies, common.

P. verticillata L. Prairies, probably rare. Dr. C. C. Parker, coll.

LEGUMINOSÆ.

Baptisia leucophœa Nutt. Prairies, frequent.

B. leucantha Torr and Gray. Prairies, frequent.

Trifolium pratense L. Cultivated and spontaneous, common.

T. repens L. Cultivated and spontaneous, common.

T. procumbens L. Rare. Dr. C. C. Parker, coll.

Melilotus officinalis Willd. Waste ground, rare.

M. alba Lam. Waste ground, infrequent.

Amorpha canescens Pursh. Prairies, infrequent.

A. fruticosa L. River banks, frequent.

Petalostemon violaceus Michx. Prairies, common.

P. candidus Michx. Prairies and open woods, common.

Tephrosia virginiana Pers. Rare. Collected by Miss Gem E. Rounds near Clermont.

Robinia pseudacacia L. Cultivated and rarely escaped.

Wistaria frutescens Poir. (?) Rare. Miss Gem E. Rounds, coll., whose specimen was too fragmentary for certain determination. Whether this or not, the plant is no leguminous plant ever reported in Iowa.

Astragalus caryocarpus Ker. Prairies, frequent.

A. canadensis L. Borders of woods, infrequent.

Desmodium acuminatum D. C. Woods, common.

D. illinoense Gray. Prairies, frequent.

D. paniculatum D. C. Low prairies, rare. Approaches *D. dillenii*, Darl.

D. canadense D. C. Woods and prairies, common.

D. sessilifolium Torr. and Gray. Prairies, infrequent.

Lespedeza leptostachya Engelm. Dry woods, a single specimen collected.

L. capitata Michx. Prairies, frequent.

Vicia caroliniana Walt. River banks, rare. Dr. C. C. Parker, coll.

V. americana Muhl. River banks, rare.

Lathyrus ochroleucus Hook. Prairies along borders of woods, rare.

L. venosus Muhl. Wooded hillsides, frequent.

L. palustris D. Borders of swamps, infrequent.

Amphicarphe monoica Nutt. Woods, probably rare. Dr. C. C. Parker, coll.

A. pitcheri Torr. and Gray. Woods, probably common. First reported in 1892 by Prof. B. Shimek, Bull. Lab. Nat. Hist, State University 3: 202. F. 1896. Mr. R. B. Wylie showed me the same species from Jackson county.

Cassia chamæcrista L. Sandy ground, frequent.

Gymnocladus canadensis Lam. Woods, rare. Dr. C. C. Parker, coll., who has a tree in his yard transplanted from the woods.

Gleditschia tricanthos L. Woods, rare.

ROSACEÆ.

Prunus americana Marsh. Thickets and woods, frequent.

P. pennsylvanica L. Woods, rare.

P. virginiana L. Woods, frequent.

P. serotina Ehrh. Woods, infrequent.

Spiræa salicifolia L. Low prairies, frequent.

Physocarpus opulifolius Maxim. Rocky banks, frequent.

Rubus strigosus Michx. Woods, infrequent.

R. occidentalis L. Woods, frequent.

R. villosus Ait. Woods, infrequent.

Geum album Gmelin. Woods, frequent.

G. virginianum L. Woods and borders, infrequent.

G. triflorum Pursh. Dry hills, rare.

G. strictum Ait. Low ground, rare. Dr. C. C. Parker, coll.

Fragaria virginiana Mill., var. *illinoensis* Gray. Low prairies and woods, common.

F. vesca L. Rocky ground, infrequent.

Potentilla arguta Pursh. Prairies, frequent.

P. norvegica L. Low ground near streams, common.

P. rivalis Nutt. Sandy ground, probably rare.

P. canadensis L. Waste ground and open woods, common.

Agrimonia eupatoria L. Woods, common.

Rosa blanda Ait. Prairies and open woods, common.

R. arkansana Porter. Prairies, rare.

Pyrus coronaria L. Woods, frequent.

Cratægus coccinea L. Woods, common. Varieties may occur.

C. punctata Jacq. Woods, frequent.

C. tomentosa L. (?) Woods, infrequent. Plant collected not satisfactory.

Amalanchier canadensis Torr. and Gray. Along streams, frequent.

A. canadensis Torr. and Gray, var. *oblongifolia* Torr. and Gray. With the last, infrequent.

SAXIFRAGACEÆ.

Saxifraga pennsylvanica L. Low prairies, common.

Mitella diphylla L. High woods, common.

Heuchera hisrida Pursh. Prairies, common.

Prnassia caroliniana Michx. River banks, rare.

Ribes cynosbati L. Woods, frequent.

R. gracile Michx. Woods, frequent.

R. floridum L'Her. Woods, infrequent.

CRASSULACEÆ.

Penthorum sedoides L. Wet ground, frequent.

UMAERLLIFERÆ.

Lythrum alatum Pursh. Low ground, common.

ONAGRACEÆ.

Ludwigia polycarpa Short and Peter. Borders of swamps, infrequent.

L. palustris Ell. Swamps, common.

Epilobium lineare Muhl. Bogs, rare.

E. coloratum Muhl. Low ground, common.

Oenothera biennis L. Waste ground, frequent.

Oe. rhombipetala Nutt. Dry soils, infrequent.

Oe. serrulata Nutt. Dry prairies, frequent.

Circæa lutetiana L. Woods, common.

CUCURBITACEÆ.

Echinocystis lobata Torr. and Gray. Banks of streams, infrequent.

FICOIDEÆ.

Mollugo verticillata L. Sandy ground, common.

UMBELLIFERÆ.

Daucus carota L. Occasionally escaped.
Heracleum lanatum Michx. Woods and openings, frequent.
Pastinaca saliva L. Occasionally escaped.
Thaspium aureum Nutt. Low prairies and woods, frequent.
Pimpinella integerrima Benth. and Hook. Rocky hills, rather rare.

Cryptocenia canadensis L. Woods, common.
Sium cicutifolium Gmelin. Low prairies, frequent.
Carum carui L. Frequently escaped.
Cicuta maculata L. Borders of ponds, infrequent.
Osmorrhiza brevistylis DC. Woods, frequent.
O. longistylis DC. Woods, frequent.
Eryngium yuccifolium Michx. Low prairies, common.
Sanicula marylandica L. Woods, common.

ARALIACEÆ.

Aralia racemosa L. Woods, infrequent.
A. nudicaulis L. Woods, frequent.
A. quinquefolia D. and Planch. Woods, rare.

CORNACEÆ.

Cornus circinata L'Her. Woods, frequent.
C. sericea L. Low woods, infrequent.
C. stolonifera Michx. Low grounds, rare.
C. paniculata L'Her. Wooded river banks, frequent.
C. alternifolia L. Wooded river banks, infrequent.

CAPRIFOLIACEÆ.

Adoxa moschatellina L. Growing about old stumps, rare. Only other locality known in Iowa is at Decorah, where Mr. E. W. D. Holway finds it.

Sambucus canadensis L. Low woods and clearings, frequent.
S. racemosa L. (?) Dr. C. C. Parker says this plant has occurred here, but I have not seen a specimen.

Viburnum opulus L. River banks, rare.
V. pubescens Pursh. Rocky woods, infrequent.
V. lentago L. Woods and clearings, frequent.

Triosteum perfoliatum L. Woods, common.

Symphoricarpos occidentalis Hook. Borders of woods and prairies, infrequent.

Lonicera tartarica L. Two or three plants along the Volga river.

L. sullivantii Gray. Woods, common.

L. glauca Hill. Woods, common.

Diervilla trifida Moench. A single plant was collected along the Volga river by Mr. A. S. Skinner. Elsewhere reported in Iowa only at Decorah by Mr. E. W. D. Holway.

RUBIACEÆ.

Galium aparine L. Low woods, common.

G. boreale L. Low prairies and banks of streams, common.

G. trifidum L. Low ground, common.

G. trifidum L., var. *latifolium* Torr. Low ground, infrequent.

G. triflorum Michx. Woods, frequent. May be *G. asprellum* Michx. instead.

VALERIANACEÆ.

Valeriana edulis Nutt. Wet prairies, common.

COMPOSITÆ.

Veronia fasciculata Michx. Low ground, frequent.

Eupatorium purpureum L. Low ground, common.

E. serotinum Michx. Borders of woods, rare.

E. altissimum L. Dry ground, infrequent.

E. perfoliatum L. Low ground, common.

E. ageratoides L. Woods, common.

Kuhnia eupatorioides L. Dry prairies, abundant.

K. eupatorioides L., var. *corymbulosa* Torr. and Gray. With the last, probably frequent.

Liatris cylindrica Michx. Prairies, common.

L. scariosa Willd. Prairies, frequent.

L. pycnostachya Michx. Prairies, common.

Solidago latifolia L. Woods, common.

S. speciosa Nutt. Dr. C. C. Parker, coll., probably rare.

S. ulmifolia Muhl. Open woods and prairies, frequent.

S. missouriensis Nutt. Prairies, infrequent.

S. serotina Ait. Prairies, infrequent.

S. serotina Ait., var. *gigantea* Gray. Prairies, common.

S. nemoralis Ait. Dry prairies, infrequent.

S. canadensis L. Prairies, common.

S. rigida L. Dry prairies, common.

S. lanceolata L. Low prairies, infrequent. Dr. C. C. Parker and Mr. J. R. Gardner have both collected the plant.

Aster oblongifolius Nutt., var. *rigidulus* Gray. Dry prairies, rare.

- A. novæ-anglicæ* L. Low prairies, frequent.
- A. sericeus* Vent. High prairies, frequent.
- A. shortii* Hook. Prairies, rare. Has the hairy petioles of *A. azureus* Lindl., and the leaves are also slightly pubescent above.
- A. undulatus* L. Prairies. J. R. Gardner, coll. Specimen not very satisfactory.
- A. cordifolius* L. Borders of woods, infrequent.
- A. sagittifolius* Willd. Borders and open woods, common.
- A. lævis* L. Prairies and open woods, common.
- A. multiflorus* Ait. Dry prairies, abundant.
- A. diffusus* Ait. Low ground, common.
- A. paniculatus* Lam. Low ground, abundant.
- A. novi-belgii* L. (?) Dr. C. C. Parker, coll. Specimen fragmentary.
- A. prenanthoides* Muhl. Low ground, rather rare.
- A. umbellatus* Mill. Low woods and prairies, frequent.
- Erigeron canadensis* L. Waste ground, abundant.
- E. annuus* Pers. Waste ground, common.
- E. strigosus* Muhl. Waste ground, frequent.
- E. bellidifolius* Muhl. Moist woods, common.
- E. philadelphicus* L. Moist woods, frequent.
- Antennaria plantaginifolia* Hook. High woods and prairies, common.
- Gnaphalium polycephalum* Michx. Fields and open woods, frequent.
- Polymnia canadensis* L. Shaded moist places, infrequent.
- Silphium laciniatum* L. Prairies, common.
- S. integrifolium* Michx. Low prairies and open woods, frequent.
- S. perfoliatum* L. Along streams, infrequent.
- Parthenium integrifolium* L. Prairies and open woods, common.
- Ambrosia trifida* L. Moist ground, common.
- A. trifida* L., var. *integrifolia* (Muhl.) Torr. and Gray. With the last or in dry places, infrequent.
- A. artemisiæfolia* L. Waste ground, abundant.
- A. psilostachya* D. C. Waste ground, only two small patches known here.
- Xanthium canadense* Mill. Waste ground, frequent.
- Heliopsis scabra* Dunal. Prairies, frequent.
- Echinacea augustifolia* DC. Prairies, frequent.
- Rudbeckia laciniata* L. Low ground, common.

- R. triloba* L. Dry prairies, common.
- R. subtomentosa* Pursh. Prairies, infrequent. Dr. C. C. Parker, coll.
- R. hirta* L. Prairies, frequent.
- Lepachys pinnata* Torr. and Gray. Prairies, common.
- Helianthus annuus* L. Waste ground, infrequent.
- H. rigidus* Desf. Prairies, frequent.
- H. occidentalis* Riddell. Prairies, common.
- H. lœtiflorus* Pers. Prairies, rare. Dr. C. C. Parker, coll.
- H. grosse-serratus* Martens. Prairies, frequent. One plant placed here after comparison must be a very unusual form, or a different species; others are the usual form.
- H. giganteus* L. Low ground, rare.
- H. giganteus* L, var. *ambiguus* Torr. and Gray. Prairies, frequent. The plant may be *H. maximiliani* Shrad. instead.
- H. divaricatus* L. (?) Dr. C. C. Parker, coll. Specimen not certain.
- H. hirsutus* Raf. Dry prairies, frequent.
- H. strumosus* L. Low ground, frequent.
- H. tracheliiifolius* Willd. Low thickets, rare.
- H. tuberosus* L. Prairies and borders, frequent.
- Coreopsis palmata* Nutt. Prairies, common.
- Bidens frondosa* L. Low ground, abundant.
- B. connata* Muhl. Wet ground, common.
- B. connata* Muhl., var. *comosa* Gray. With the last, frequent.
- B. cernua* L. Wet ground, probably common. Dr. C. C. Parker, coll.
- B. chrysanthemoides* Michx. Wet ground, frequent.
- Helenium autumnale* L. Moist ground, common.
- Anthemis cotula* L. Waste ground, abundant.
- Achillea millefolium* L. Prairies, common.
- Tanacetum vulgare* L. Occasionally escaped.
- Artemisia caudata* Michx. Sandy soil, common.
- A. dracunculoides* Pursh. Sandy river banks, infrequent.
- A. serrata* Nutt. Low prairie, rare.
- A. ludoviciana* Nutt. Prairie, common and variable.
- A. biennis* Willd. Sandy soil, rare. Dr. C. C. Parker, coll.
- A. absinthium* L. Rarely escaped. Dr. C. C. Parker, coll.
- Senecio aureus* L. Low ground, common.
- S. aureus* L., var. *balsamitæ* (Muhl.) Tarr. and Gray. With the last, probably rare.
- Cacalia suaveolens* L. Borders of woods, infrequent.

C. reniformis Muhl. Open damp woods, frequent.

C. tuberosa Nutt. Low prairies, frequent.

Erechtites hieracifolia Raf. Moist ground, rare. Dr. C. C. Parker, coll.

Arctium lappa L. Waste ground, common. Probably varieties occur.

Oniscus lanceolatus Hoffm. Pastures and waste ground, common.

C. Altissimus Willd. Low woods, frequent.

C. Altissimus Willd., var. *discolor* Gray. Waste ground, frequent.

C. Arvensis Hoffm. Mr. C. F. Paine reports this plant from two places in Fayette county.

Krigia amplexicaulis Nutt. Woods, common.

Cichorium intybus L. Roadsides, infrequent.

Tragopogon pratensis L. A single specimen collected in a street of Fayette. Not before reported in Iowa.

Hieracium canadense Michx. Open woods and prairies, frequent.

H. scabrum Michx. Woods, rare. Mr. R. B. Wylie, coll.

Prenanthes racemosa Michx. Low prairies, infrequent

P. aspera Michx. Prairies, rare. Dr. C. C. Parker, coll.

P. alba L. Woods and borders, frequent.

Troximon cuspidatum Pursh. High prairies, rare.

Taraxacum officinale Weber. Pastures, yards, etc., abundant.

Lactuca scariola L. Waste ground, rare. First collected in 1895. Will probably soon become common.

L. canadensis L. Waste ground, common.

L. floridana Gaertn. Rare. Dr. C. C. Parker, coll.

L. leucophæa Gray. Rare. Dr. C. C. Parker, coll.

Sonchus oleraceus L. Waste ground, common.

S. asper Vill. Waste ground, rare or confused with the above. Dr. C. C. Parker, coll.

LOBELIACEÆ.

Lobelia cardinalis L. Along streams, rarely occurs in the western part of Fayette county.

L. syphilitica L. Low ground, common.

L. spicata Lam. Prairies, frequent.

L. spicata Lam., var. *hirtella* Gray. With the last, seldom observed.

L. inflata L. Open woods and borders, infrequent.

CAMPANULACEÆ

- Specularia perfoliata* A. D. C. Open woods, frequent.
Campanula rotundifolia L. Rocky places, common.
C. aparinoides Pursh. Borders of swamps, infrequent.
C. americana L. Moist places, common.

ERICACEÆ.

- Chimaphila umbellata* Nutt. Woods, only a dozen plants known in one place.
Pyrola elliptica Nutt. Woods, common.
Monotropa uniflora L. Woods, rare.

PRIMULACEÆ.

- Dodecatheon media* L. Prairies, common.
Steironema ciliatum Raf. Low ground, common.
S. lanceolatum Gray. Low ground, common.
S. longifolium Gray. Low ground, common.
Lysimachia stricta Ait. Low ground, rare.
L. thyrsiflora L. Swamps, rare.

OLEACEÆ.

- Fraxinus americana* L. Woods, infrequent.
F. viridis Michx. Low woods, apparently rare.
F. quadrangulata Michx. A single tree known to me.

APOCYNACEÆ.

- Apocynum androsæmifolium* L. Borders of woods, common.
A. cannabinum L. Moist ground, common.

ASCLEPIDACEÆ.

- Asclepias tuberosa* L. Prairies, common.
A. incarnata L. Low ground, common.
A. cornuti Decaisne. Waste ground, common.
A. sullivantii Engelm. Low ground, frequent.
A. phytolaccoides Pursh. Low ground, rare.
A. ovalifolia Decaisne. Prairies, rare. Dr. C. C. Parker, coll.
A. verticillata L. Prairies, infrequent.
Acerates longifolia Ell. Prairies, infrequent.
A. viridiflora Ell., var. *lanceolata* Gray. Prairies, rare.

GENTIANACEÆ.

- Gentiana crinita* Froel. Rare. Dr. C. C. Parker, coll., who assures me that the plant was common ten years ago. Mr. J. R. Gardner collected it in 1896.

G. quinqueflora Lam., var. *occidentalis* Gray. Borders of woods, becoming common.

G. puberula Michx. Dry prairies, rare.

G. andrewsii Griseb. Low prairies, infrequent.

G. alba Muhl. Low ground, rare.

POLEMONIACEÆ.

Phlox paniculata L. Rare and probably escaped. Mr. J. R. Gardner, coll.

P. maculata L. Low ground, infrequent.

P. pilosa L. Low prairies, common.

P. divaricata L. Woods, common.

P. subulata L. In cemetery, probably escaped.

Polemonium reptans L. Woods, abundant.

HYDROPHYLLACEÆ.

Hydrophyllum virginicum L. Woods, abundant.

H. appendiculatum Michx. Low woods, rare.

Ellisia nyctelea L. Moist, shady ground, common.

BORRAGINACEÆ.

Echinosperrum virginicum Lehm. Woods, common.

E. lappula Lehm. Waste ground, common.

Mertensia virginica (L.) D. C. Woods, abundant.

Lithospermum officinale L. Border of woods, one patch known. Not previously reported in Iowa.

L. latifolium Michx. Rare, Dr. C. C. Parker, coll.

L. hirtum Lehm. Prairies, infrequent.

L. canescens Lehm. Prairies, common.

L. angustifolium Michx. High prairies, common. The form formerly considered a distinct species under the name of *L. longiflorum* Spreng, occurs commonly on hillsides and is quite distinct.

Onosmodium carolinianum A. D. C., var. *molle* (Michx.) Gray. Waste ground, common.

CONVOLVULACEÆ.

Ipomœa coccinea L. Rarely escaped.

I. purpurea Lam. Frequently escaped.

Convolvulus sepium L. Low ground, frequent.

C. arvensis L. In yards, rare.

Cuscuta inflexa Engelm. On various plants, infrequent.

C. tenuiflora Engelm. On willows in low ground, frequent.

C. glomerata Choisy. Low ground, probably rare. Mr. J. R. Gardner, coll.

SOLANACEÆ.

Solanum triflorum Nutt. A single plant collected along the Volga river in 1895. Not before reported in Iowa.

S. nigrum L. Low ground, common.

S. heterodoxum Danal. Growing along a street in Fayette. Doubtless introduced. Not before reported in Iowa.

Physalis philadelphica L. A single plant collected in a field in 1896.

P. pubescens L. Waste ground, common.

P. virginiana Mill. Waste ground, frequent.

P. lanceolata Michx. Waste ground, infrequent.

Datura stramonium L. Waste ground, infrequent.

D. tatula L. Waste ground, infrequent.

SCROPHULARIACEÆ.

Verbascum thapsus L. Waste ground, frequent.

Linaria vulgaris Mill. Waste ground, infrequent.

Scrophularia nodosa L. var. *marilandica* Gray. Low prairies, common.

Chelone glabra L. Wet ground, frequent.

Mimulus ringens L. Wet ground, common.

Conoclea multifida Benth. A single plant collected in 1894. Reported by J. C. Arthur from Lee county.

Gratiola virginiana L. Low ground, frequent.

Ilysanthes riparia Raf. Wet ground, common.

Synthyris houghtoniana Benth. Prairies, rare. Dr. C. C. Parker, coll.

Veronica virginica L. Woods and prairies, common.

V. anagallis L. About springs, infrequent.

V. peregrina L. Low waste ground, common.

Gerardia auriculata Michx. Low prairies, infrequent.

G. purpurea L. Low ground, common.

G. tenuifolia Vahl. Dry prairies, rare.

Castilleja coccinea Spreng. Woods and prairies, common. Flowers commonly yellow on the prairies.

C. sessiliflora Pursh. High prairies, infrequent.

Pedicularis canadensis L. Prairies and open woods, common.

P. lanceolata Michx. Moist woods, infrequent.

LENTIBULARIACEÆ.

Utricularia vulgaris L. Ponds, infrequent.

VERBENIACEÆ.

- Verbena urticifolia* L. Low ground, common.
V. hastata L. Low ground, common.
V. stricta Vent. Prairies, frequent.
V. bracteosa Michx. Waste ground, common.
Phryma leptostachya L. Low woods, frequent.

LABIATÆ.

- Isanthus cœruleus* Michx. Dry hills, frequent.
Teucrium canadense L. Moist ground, abundant.
Mentha canadensis L. Moist ground, abundant.
Lycopus virginicus L. Moist ground, common.
L. sinuatus Ell. Moist ground, common.
Pycnanthemum lanceolatum Pursh. Prairies, infrequent.
Hedeoma pulegioides Pers. Dry hills, rare.
H. hispida Pursh. Dry ground, common.
Salvia lanceolata Willd. Specimen collected in 1894, but lost.
S. officinalis L. Persisting after cultivation.
Monarda fistulosa L. Prairies and woods, common.
Blephilia hirsuta Benth. Moist woods, infrequent.
Lopanthus nepetoides Benth. Borders of woods, infrequent.
L. scrophulariaceifolius Benth. Borders of woods, infrequent.
Nepeta cataria L. Waste ground, common.
N. glechoma Benth. Yards, etc., common.
S. versicolor Nutt. River banks, infrequent.
Scutellaria lateriflora L. River banks, frequent.
S. parvula Michx. High prairies, frequent.
S. galericulata L. Wet shady ground, rare.
Brunella vulgaris L. Open woods and waste ground, common.
Physostegia virginiana Benth. Low ground, common.
Marrubium vulgare L. Probably escaped, rare. Dr. C. C. Parker, coll. Mr. R. B. Wylie also collected it in Jackson county in 1896. Not before reported in Iowa.
Leonurus cardiaca L. Yards, etc., frequent.
Stachys palustris L. Wet ground. Dr. C. C. Parker, coll.
S. aspera Michx. Wet ground. Dr. C. C. Parker, coll.
S. aspera Michx., var. *glabra* Gray. Wet ground. Dr. C. C. Parker, coll. Probably all three species of the genus are rare.

PLANTAGINACEÆ.

- Plantago major* L. Waste ground, common.
P. rugelii Decaisne. Waste ground, frequent.
P. lanceolata L. Yards, rare. Miss Gem E. Rounds, coll.
P. patagonica Jacq., var. *gnaphalioides* Gray. Sandy ground in western part of Fayette county and common in parts of Bremer county. Hitherto only reported from western Iowa. (Proc. Iowa Acad. Science, 3:129, 1895.)

NYCTAGINACEÆ.

- Oxybaphus nyctagineus* Sweet. Sandy river banks, frequent.

AMARANTACEÆ.

- Amarantus albus* L. Waste ground, common.
A. blitoides Watson. Waste ground, frequent.
A. retroflexus L. Cultivated fields, etc., frequent.
Acnida tuberculata Moq. Low waste ground, frequent.

CHENOPODIACEÆ.

- Chenopodium boscianum* Mcq. Waste ground, frequent.
C. album L. Waste ground, common.
C. hybridum L. Cultivated fields and waste ground, frequent.
C. bonus-henricus L. (?) Waste ground, rare. Specimen immature, carefully compared.
C. botrys L. Sandy river banks, rare.
Salsola kali L., var. *tragus* D.-C. Introduced along the railroad. One specimen collected in 1895 and another in 1896. Likely to become common in a few years.

POLYGONACEÆ.

- Rumex patientia* L. A single patch known. Found in 1894 by Dr. C. C. Parker and the writer. New to Iowa. Determined by Mr. John K. Small.
R. altissimus Wood. Moist ground, frequent. *R. salicifolius* Weinmann may occur here also. The above determined by Mr. John K. Small.
R. verticillatus L. Swamps, rare.
R. crispus L. Waste ground, etc., common.
R. acetosella L. Waste ground, common.
Polygonum aviculare L. Waste ground, abundant.
P. erectum L. Waste ground, common.
P. ramosissimum Michx. Moist, sandy ground, frequent.

- P. lapathifolium* L. Wet ground, frequent.
P. pennsylvanicum L. Moist ground, common.
P. muhlenbergii Watson. Swamps, rare.
P. orientale L. Escaped. Dr. C. C. Parker, coll.
P. persicaria L. Waste ground, frequent.
P. hydropiperoides Michx. Wet ground, infrequent.
P. hydropiper L. Moist ground, infrequent.
P. acre H B K Wet ground, common.
P. virginianum L. Rich woods, common.
P. sagittatum L. Moist ground, frequent.
P. convolvulus L. Waste ground and fields, common.
P. dumetorum L., var., *scandens* Gray. Moist thickets, infrequent.
Fagopyrum esculentum Moench. Occasionally escaped.

ARISTOLOCHIACEÆ.

- Asarum canadense* L. Wooded hillsides, frequent.

THYMELÆACEÆ.

- Dirca palustris* L. Dry prairies, common.

SANTALACEÆ.

- Comandra umbellata* Nutt.

EUPHORBIACEÆ.

- Euphorbia serpyllifolia* Pers. Waste ground, frequent.
 Seems to run into *E. glyptosperma* Engelm.
E. maculata L. Waste ground, common and variable.
E. preslii Guss. Waste ground, infrequent.
E. corollata L. Prairies and open woods, common.
E. heterophylla L. Rocky river banks, rare.
E. cyparissias L. Rarely escaped.
Acolypha virginica L. Waste ground, common.

URTICACEÆ.

- Ulmus fulva* Michx. Woods, frequent.
U. americana L. Low woods along streams, frequent.
U. racemosa Thomas. Several trees known in one place in low woods.
Celtis occidentalis L. Open woods along the Volga river, infrequent.
Cannabis sativa L. Waste ground, frequent.
Humulus lupulus L. Open woods, infrequent.
Urtica gracilis Ait. Moist ground, frequent.

Laportea canadensis Gaudichaud. Low moist woods, common.

Pilea pumila Gray. Low woods, frequent.

Bæhmeria cylindrica Willd. Low woods, frequent.

JUGLANDACEÆ.

Juglans cinerea L. Woods, frequent.

J. nigra L. Woods, frequent.

Carya alba Nutt. Woods, infrequent here, but common along streams in Bremer county.

C. amara Nutt. Woods, frequent.

CUPULIFERÆ.

Betula papyrifera Marshall. Woods, infrequent.

B. nigra L. Woods, frequent on the Turkey river.

Corylus americana Walt. Thickets and open woods, common.

Ostrya virginica Willd. Woods, frequent.

Carpinus caroliniana Walter. Woods, along streams, frequent.

Quercus alba L. Woods, frequent ten miles northeast of Fayette.

Q. macrocarpa Michx. Woods, common.

Q. muhlenbergii Engelm. Woods on the Turkey river, infrequent.

Q. rubra L. Woods, frequent twelve miles northeast of Fayette.

Q. coccinea Wang. Woods, common.

Q. coccinea Wang., var. *tinctoria* Gray. Woods, infrequent.

SALICACEÆ.

Salix nigra Marsh. Along streams, frequent.

S. amygdaloides Anders. Low ground, frequent.

S. lucida Muhl. Low ground, frequent.

S. fragilis L., *X. alba* L. Low ground, rare and probably introduced and escaped. Not before reported in Iowa.

S. longifolia Muhl. Low ground, common.

S. rostrata Richardson. Low prairies, infrequent.

S. discolor Muhl., var. *prinoides* Anders. Low ground, common. Perhaps not the variety.

S. humilis Marsh. Prairies, frequent.

S. sericea Marsh. Low ground, frequent. Mr. Bebb expressed surprise at finding this here, especially a "pure form," which he said replaces *S. petiolaris* Smith.

S. sericea Marsh, *X. cordata* Muhl. Low ground, apparently frequent. *S. sericea* with serrate leaves. Not before reported in Iowa.

S. cordata Muhl. Low ground, rare.

S. cordata Muhl., *X. sericea* Marsh. Low ground. Not before reported in Iowa. Mr. Bebb wrote that *S. myricoides* Muhl. is a synonym. Leaves nearly entire and a different plant from the second above.

Populus tremuloides Michx. Woods, common.

P. grandidentata Michx. Woods, common.

P. monilifera Ait. Frequently coming up from seeds of planted trees. Dr. C. C. Parker feels sure that it occurs along our streams. If so, I have failed to notice it.

CERATOPHYLLACEÆ.

Ceratophyllum demersum L. Ponds infrequent.

CONIFERÆ.

Pinus strobus L. Woods, occasionally seen about Wadena.

Juniperus communis L. Wooded hills along streams, common.

J. virginiana L. At top of wooded bluffs, frequent.

Taxus canadensis Willd. At the base of wooded bluffs, frequent.

HYDROCHARIDACEÆ.

Elodea canadensis Michx. Ponds, infrequent.

Vallisneria spiralis L. In Volga river, rare.

ORCHIDACEÆ.

Aplectrum hiemale Nutt. Woods, frequent.

Spiranthes cernua Richard. Prairies, rare. Mr. J. R. Gardner, coll.

Calopogon pulchellus R. Br. Prairies at Wadena, rare.

Pogonia pendula Lindl. Rich woods, rooting in decayed wood and blooming in August or September, rare.

Orchis spectabilis L. Woods, frequent.

Habenaria tridentata Hook. Prairies at Wadena, rare. First reported for Iowa by the writer. Proc. Iowa Acad. Sci., 1: 103, 1893.

H. bracteata R. Br. Woods, rare.

H. hookeri Torr. Woods, rare.

H. hookeri Torr., var. *oblongifolia* Paine. Woods, rare. First reported for Iowa by the writer. Proc. Iowa Acad. Sci., 1: 103, 1893.

H. leucophcea Gray. Woods, rare. Dr. C. C. Parker, coll.

H. psycodes Gray. Woods, three plants collected in 1893.

First reported for Iowa by the writer. Proc. Iowa Acad. Sci., 1: 103, 1893.

Cypripedium candidum Muhl. Low prairies, rare.

O. pubescens Willd. Woods, infrequent.

C. spectabile Salisb. Low woods and prairies, rare.

IRIDACEÆ.

Iris versicolor L. Wet prairies about ponds, frequent.

Sisyrinchium angustifolium Mill. Low prairies, common.

AMARYLLIDACEÆ.

Hypoxis erecta L. Prairies, common.

DIOSCOREACEÆ.

Dioscorea villosa L. A single plant was collected in 1894 along border of woods.

LILIACEÆ.

Smilax herbacea L., var. *pulverulenta* Gray. Woods, rare.

S. ecirrhata Watson. Woods, frequent. Apparently uncommon in Iowa as it was not reported till 1896. Prof. B. Shimek in Bull. Lab. Nat. Hist. Iowa State University, 3: 199, F. 1896. Our most common smilax.

S. hispida Muhl. Moist woods, infrequent.

Allium tricoccum Ait, woods, frequent.

A. canadense Kalm. Moist river banks, frequent.

Polygonatum biflorum Ell. A single plant collected along a wooded hillside.

P. giganteum Dietrich. Low open woods, infrequent,

Asparagus officinalis L. Occasionally escaped.

Smilacina racemosa Desf. Woods, common.

S. stellata Desf. Low prairies, infrequent.

Mianthemum canadense Desf. Upland woods, frequent.

Uvularia grandiflora Smith. Woods, frequent.

Oakesia sessilifolia Watson. Woods, frequent.

Erythronium albidum Nutt. Woods, common.

Lilium philadelphicum L. Low prairies, frequent.

L. canadense L. Low prairies, frequent.

Trillium erectum L. Low woods, common. The form called *T. erectum* L., var. *declinatum* Gray, occurs here and is mistaken locally for *T. recurvatum* Beck.

T. cernuum L. Low woods, infrequent.

T. nivale Riddell. Several plants were collected in 1895 by Miss Etna Burette.

XYRIDACEÆ.

Xyris flexuosa Muhl. Low prairies, apparently rare.

COMMELINACEÆ.

Tradescantia virginica L. Low prairies, common. Flowers frequently rose-colored or nearly white.

JUNCACEÆ.

Juncus tenuis Willd. Prairies, woods and pastures, abundant.

J. nodosus L. Low, sandy ground, common.

TYPHACEÆ.

Typha latifolia L. Sloughs, common.

Sparganium eurycarpum Engelm. Swamps, infrequent.

S. simplex Huds. Swamps, infrequent.

ARACEÆ.

Arisæma triphyllum Torr. Woods, common.

A. dracontium Schott. Low woods, infrequent.

Symplocarpus fetidus Salisb. One patch known near Wadena on wet ground. Apparently a rare Iowa plant.

Acorus calamus L. Swamps, frequent.

LEMNACEÆ.

Spirodela polyrrhiza Schleid. Ponds, abundant.

Lemna trisulca L. Ponds, infrequent.

L. minor L. Ponds, common.

ALISMACEÆ.

Alisma plantago L. Ponds, common.

Sagittaria heterophylla Pursh. Wet ground or in water, common and very variable. Mr. Cratty writes of the specimens sent him, "What a maze of forms."

S. variabilis Engelm. Wet ground or in water, probably infrequent. For the sake of uniformity I have followed Gray in synonymy here instead of Mr. Cratty's paper, Bull. Lab. of Nat. Hist., State University of Iowa 3: 136, F. 1896, though the latter doubtless offers many improvements. The same is true of all the aquatic plants.

NAIADACEÆ.

Potamogeton pennsylvanicus Cham. In water, frequent.

P. fluitans Roth. In streams, frequent.

P. mucronatus Schrad. In still water, frequent. Mr. Cratty writes, "probably this, but too imperfect for correct determination."

CYPERACEÆ.

Cyperus diandrus Torr. Low sandy ground, frequent.

C. diandrus Torr., var. *castaneus* Torr. With the last, probably rare.

C. aristatus Rottb. Low sandy ground, common.

C. schweinitzii Torr. Sandy ground, frequent.

C. filiculmis Vahl. Sandy soil, infrequent.

C. esculentus L. Low ground and cultivated fields, frequent.

C. strigosus L. Low, sandy ground, frequent.

Eleocharis ovata R. Br. Wet ground, infrequent.

E. palustris R. Br. Wet ground, abundant.

E. acicularis R. Br. Wet ground, abundant.

Scirpus lacustris L. Swamps, common.

S. atrovirens Muhl. Wet ground, common.

Eriophorum cyperinum L. Low ground, frequent.

E. polystachyon L. Wet ground, rare and variable.

Carex lupulina Muhl. Sloughs, frequent.

C. retrorsa Schwein. Miss Ona M. Rounds, coll. Determined by Mr. Cratty.

C. stricta Lam. Sloughs, common.

C. stricta Lam., var. *decora* Bailey. Sloughs, infrequent.

C. longirostris Torr. Low sandy ground, frequent.

C. aquatilis Wahl. Wet ground in mud or water, frequent.

The plants examined were young.

C. laxiflora Lam. Some doubt as to habit, and Mr. Cratty writes that is an unusual form of the species.

C. pedunculata Muhl. Shaded bluffs, infrequent.

C. varia Muhl. Mr. Fernald says the plant was too young to be certain.

C. pennsylvanica Lam. Woods and prairies, common.

C. stipata Muhl. Wet ground, common.

C. vulpinoidea Michx. Miss Ona M. Rounds, coll. Determined by Mr. Cratty.

C. rosea Schkuhr. Woods, common.

C. interior Bailey. Bull. Torr. Bot. Club, 20: 426, N. 1883. Probably common. Probably confused formerly in Iowa as some form of *C. echinata* Murray. Not before reported from Iowa.

C. cephalophora Muhl. Mr. A. S. Skinner, coll. Determined by Mr. Cratty,

C. tribulo'ides Wahl. Wet ground, frequent.

C. tribuloides Wahl., var. *reducta* Bailey. Wet ground, probably frequent.

C. tribuloides Wahl, var. *bebbii* Bailey. Mr. A. S. Skinner, coll. Determined by Mr. Cratty, who also saw the other two forms of the species.

C. scoparia Schkuhr. Low ground, frequent.

C. straminea Willd. Low ground, frequent.

GRAMINEÆ.

Spartina cynosuroides Willd. Low prairies, common.

Panicum glabrum Gaudin. Waste ground, frequent.

P. sanguinale L. Cultivated and waste ground, common.

P. proliferum Lam. Waste ground, infrequent.

P. capillare L. Waste and cultivated ground, common.

P. virgatum L. Low prairies, infrequent.

P. latifolium L. Woods, frequent.

P. dichotomum L. Woods and waste ground, common.

P. crus-galli L. Waste ground, common.

Setaria glauca Beauv. Cultivated and waste ground, abundant.

S. viridis Beauv. Cultivated and waste ground, abundant.

S. italica Kunth. Frequently escaped.

Cenchrus tribuloides L. Sandy soil, common.

Leersia virginica Willd. Wet ground, frequent.

L. oryzoides Swartz. Wet ground, frequent.

Zizania aquatica L. Ponds, infrequent.

Andropogon furcatus Muhl. Prairies, common.

A. scoparius Michx. High prairies, frequent.

Chrysopogon nutans Benth. Prairies, frequent.

Phalaris arundinacea L. Wet ground, infrequent.

Stipa spartea Trin. High prairies, infrequent.

Oryzopsis melanocarpa Muhl. Rocky woods, infrequent.

Muhlenbergia glomerata Trin. Low ground, common.

M. mexicana Trin. Low ground, frequent.

M. sylvatica Gray. Woods, frequent.

M. diffusa Schreber. Woods, infrequent.

Brachyelytrum aristatum Beauv. Rocky woods, frequent.

Alopecurus geniculatus L., var. *aristulatus* Torr. Swamps, infrequent.

Sporobolus heterolepis Gray. Dry ground, frequent.

S. neglectus Nash., Bull. Torr. Bot. Club, 22: 463, N. 1896. Waste grounds and probably prairies, frequent. Not before reported in Iowa, but confused with *S. vaginæflorus* Vasey. Determined by George V. Nash.

Phleum pratense L. Commonly escaped.

Agrostis alba L. Meadows and roadsides, common.

A. alba L., var. *vulgaris* Thurb. Probably common as the last.

A. scabra Willd. Dry ground.

Cinna arundinacea L. Moist, wooded ravines, frequent.

Calamagrostis canadensis Beauv. Wet prairies, frequent.

Bouteloua hirsuta Lag. Sandy ground, rare. Mr. A. S. Skinner, Coll.

B. racemosa Lag. Dry prairies, common.

Phragmites communis Trin. Wet ground, rare.

Koeleria cristata Pers. Prairies, common.

Eragrostis reptans Nees. Sandy river banks, common.

E. major Host. Waste ground, common.

E. frankii Meyer. Sandy river banks, infrequent.

E. petinacea Gray. Sandy river banks, infrequent.

Melica mutica Walt. Open woods, rare.

Dactylis glomerata L. Yards, rare.

Poa pratensis L. Meadows and roadsides, common.

Glyceria nervata Trin. Low ground, common.

Festuca nutans Willd. Woods, frequent.

Bromus kalmii Gray. Dry ground, infrequent.

B. ciliatus L. Woods, common.

B. ciliatus L., var. *purgans* Gray. Woods, infrequent.

Agropyrum repens Beauv. Waste ground, infrequent.

Hordeum jubatum L. Waste ground common.

Elymus virginicus L. River banks, abundant.

E. canadensis L. River banks and waste ground, common.

E. striatus Willd. Woods, common.

Asprella hystrix Willd. Woods, common.

NEW OR LITTLE KNOWN PLANTS.

T. J. FITZPATRICK.

The following plants are new or little known to the flora of Iowa:

Lechea tenuifolia Mx. Van Buren county. Common in sandy soil. July.

Circea alpina L. Clayton county. Deep woods along the Mississippi river. Rare as compared with *C. lutetiana* L. July.

Collinsia verna Nutt. Jefferson county. Frequent.

Gilia linearis Gray. Decatur county. Frequent in prairie soil. June.

Inula helenium L. Johnson county. Common locally where it has been observed for many years.

Corallorhiza odontorhiza Nutt. Reported in Natural Science Bulletin of the State University of Iowa (Vol. 3, No. 4) as new and rare. The species was very common in several localities in Johnson county during the month of August, 1896. It occurred in deep upland woods where there was a considerable depth of decaying leaves. The plants occurred singly or collected in tufts. Often only one or two were able to pierce the mat of leaves, the remainder blooming beneath. The specimens from beneath the leaves were frequently dwarfed as well as pale in appearance, though many good specimens were found in that position. This habit of growth probably prevents the specimens from being observed by the collector. The time of gathering was from the 16th to the 30th of August, which is a month later than the limit given by Gray. About 200 specimens were collected.

MECHANISM FOR SECURING CROSS FERTILIZATION IN *SALVIA LANCEOLATA*.

G. W. NEWTON.

This plant was found growing abundantly about Grand Island, Nebraska, especially in waste places where the sod had been removed. It is 6 to 18 inches high, has lanceolate to linear, sparsely serrate leaves. The racemes are 1 to 4 inches long. The corolla is about three-eighths of an inch long and of a delicately blue tint, the upper lip forming a pubescent hood enclosing stamens and style. The lower lip is comparatively broad, three lobed and by its protrusion affords an excellent landing place for insects. The style is nearly glabrous and is bifurcated, the upper branch being exserted and curved upwards. The lower branch is slightly flattened at the end forming the stigma, which extends a little beyond the anthers in such a position that it is quite sure to come in contact with the insects entering the flower. The stamens, two in number, are peculiar. The filaments are short and attached to the lower lip of the corolla. The anthers are long, yoke shaped, one celled at the upper ends, and are attached by hinges near the middle to the filaments. They curve backward, are united the lower third of their length and rest their lower extremities on the corolla.

There is a groove down the center of the lower lip along which the insect's proboscis will be directed in searching for nectar. By this act the sterile ends of the anthers will be raised and the anther cells will descend like the ends of an old fashioned well sweep, and come into contact with the head or proboscis of the invading insect. The pollen thus secured is quite sure to be deposited on the stigma of the next flower visited, thus securing cross fertilization. After being tilted, the anthers are under tension and readily return to their former position. A little below the middle of each anther is a slightly curved projection which fits

into a groove in the lower lip of the corolla. This mechanism may thus assist the anthers to return to their normal position, or may prevent the proboscis of the insect from being thrust down the side of the corolla, and thus evading the pollen. Many small bees were seen to visit these flowers on bright days. The plant blossoms during July and August and a few flowers were found in the latter part of September.

NOTES OF SOME INTRODUCED PLANTS OF IOWA.

L. H. PAMMEL.

Since the settlement of Iowa many changes have taken place in our flora, especially with reference to introduced plants, and the disappearance of many indigenous species owing to breaking up of prairies, and the destruction of some timber areas, and the draining of ponds and lakes.

It is with difficulty that species of *Potamogeton* have been enabled to retain their hold in water, or that *Cypripedium spectabile* should maintain itself in the wooded and much pastured timbers of Iowa. With the early settlement of Iowa there came a host of European weeds. They are so well naturalized that it is no longer possible to state whether they are introduced or indigenous, nor are we able to state when they were introduced. In fact there are no early collections, and in many cases early collectors failed to note whether the plant was introduced or indigenous. We have no early records for such common weeds as *Portulaca oleracea*, *Verbascum thapsus*, *Anthemis cotula*, *Malva rotundifolia*, *Chenopodium album*. Indeed, we are unable to say how rapidly these weeds have spread. In fact when we look over our introduced plants we find that there are but few cases in which there are statistical records such as we now have for *Lactuca scariola*, *Salsola kali*, var. *tragus* or *Solanum rostratum*, *Hieracum aurantiacum* and a few others. Those who are connected with our experiment station have frequent requests to identify weeds, and it would

seem to me proper to make a record of all such plants in a card catalogue where the specimens cannot be preserved.

It is an interesting fact to note that it frequently takes years for a weed to become so well established as to attract attention. Some years ago Dr. Halsted, while connected with the Iowa Agricultural college, noted that *Solanum rostratum* had been reported to him. This plant has long occurred in western Iowa but it is only recently that it has been reported from many parts of the state, showing increased tendency to spread. It is no longer considered worth while by the average farmer to report *Lactuca scariola*, it is so thoroughly naturalized, and yet some few years ago it was seldom seen. It has undoubtedly become thoroughly acclimated over a large extent of our territory, occurring not only in streets and timbers of our own state but in the heart of the Rocky mountains far away from any habitation.

In the appended list the species are arranged according to Gray's Manual, sixth edition, also adopting the nomenclature of that work.

RANUNCULACEÆ.

Ranunculus acris L. College campus in Ames. It is scarcely persistent.

Delphinium consolida L. Corning, 1895 (Ellen Bettonier.)

PAPAVERACEÆ.

Argemone alba L. Southern Iowa near Ottumwa.

CRUCIFERÆ.

Camelina sativa Crantz. Ames, 1891 (Hitchcock). Hazleton (Knight.)

Brassica alba Boiss. Ames. Corbett in Hitchcock. (Anthophyta and Pteridophyta of Ames, 1891, p. 486) 1896. Dooryards north of agricultural building, I. A. C. campus, Geo. Carver, 1896.

Erysimum asperum D. C. Ames, 1896, along railroads undoubtedly from the west (G. W. Carver.)

Sisymbrium altissimum L. Ames, 1895, G. W. Carver.

To this should be added the localities given by L. H. Dewey, Davenport, Blue Grass, Dickens. (Circular No. 7, Division of Bot. U. S. Dept. of Agr.

CAPPARIDACEÆ.

Cleome integrifolia Torr. & Gray. Only indigenous to western Iowa, has become a common weed in Council Bluffs, Missouri Valley, Sioux City and Onawa.

CARYOPHYLLACEÆ.

Saponaria vaccaria L. Little Rock (C. R. Ball). A weed of wheat fields.

Silene cucubalus Wibel. Ames.

Silene noctiflora L. Ames, 1896.

Lychnis vespertina Sibeth. Ames, 1896, R. Combs, C. R. Ball, Geo. Carver. Red Oak, 1896, C. G. Patten.

L. githago Lam. Rock Valley, 1896 (J. F. Jensen and W. Newell). Little Rock (C. R. Ball). Ames (Hitchcock). This weed has shifted with wheat culture. I have never seen a specimen growing in central Iowa.

MALVACEÆ.

Malva rotundifolia L. Abundant in some parts of Iowa. It is frequent in central Iowa. Common in western Iowa in cities and along the Missouri river and in eastern Iowa along the Mississippi river. Little Rock, 1893 (C. R. Ball).

Hibiscus trionum L. Ames, 1890-1896. Has scarcely escaped to fields, usually about flower gardens. Muscatine (F. Reppert). LeClaire in fields (P. H. Rolfs).

Trifolium arvense L. Collected by Professor Bessey in 1871, has not been found since.

T. agrarium L. Reported by Hitchcock from Ames in 1886, has not been found since.

T. procumbens L. Ames, 1882 (Hitchcock). Occurred in Ames in 1886. Iowa city 1884 (Hitchcock). It is now frequently collected every spring.

Melilotus officinalis Willd. As yet is not common in central Iowa though abundant in Sioux City, 1895, and Council Bluffs, 1895. Also occurs in Muscatine, 1891 (F. Reppert). Iowa City, 1889 (A. S. Hitchcock). Dakota City, 1896 (L. H. Pammel).

M. alba Lam. Iowa City, 1889 (A. S. Hitchcock). Ames, frequent, 1890 (J. F. Rolfs). (F. C. Stewart) 1891. Abundant at Moingona, 1895. Boone, 1895. Council Bluffs, 1895. Sioux City, 1895, (L. H. Pammel). Iowa City, 1887 (A. S. Hitchcock). Muscatine, 1891 (F. Reppert).

Medicago sativa L. Ames occasionally, now frequent in Council Bluffs, Muscatine, 1891 (F. Reppert). Sioux City, 1896 (L. H. Pammel).

M. lupulina L. Ames, 1871 (C. E. Bessey). Has not been found since Hitchcock (Cat. Anthenphyta and Pteridophyta of Ames, p. 491) says occasionally found in waste places.

Hosackia purshiana Benth. Indigenous loess of Iowa along the Missouri river. Sioux City. Naturalized. Boone, 1895 (G. W. Carver.)

Glycyrrhiza lepieota Nutt. Ontario, 1856 (Hitchcock). Ames (A. S. Hitchcock) 1889. Greenfield, 1891 (F. C. Stewart). Spreading at near Greenfield, undoubtedly introduced indigenous to western and northwestern Iowa. It is spreading at Hull, 1895 (W. Newell). Little Rock, 1893 (C. R. Ball). Logan, 1895. Council Bluffs, 1895. Spreading at Le Mars, 1896 (W. J. Newell). Lenox, 1896 (J. L. H.). Grand Junction, 1872 (C. E. Bessey). Harrison county, 1875, Rev. Burgess.

Cassia tora L. Ames, along C. & N.-W. R. R., 1894 (C. R. Ball, Robert Combs). Not found since.

COMPOSITÆ.

Grindelia squarrosa Dunal. Indigenous to western Iowa and is rapidly spreading in contiguous territory, and has been reported from Keokuk, 1891 (P. H. Rolfs). Boone and Moin-gona, abundant in borders of woods along C. & N.-W. R. R., 1890. Battle Creek, 1895 (E. G. Preston). Osgood, 1895, C. A. Wells. Carbonado, 1895 (John H. Smith). Smithland, 1895 (J. M. Wrapp).

Iva xanthiifolia Nutt. I have given its distribution as far as Iowa is concerned quite fully in another connection. It is, however, spreading. Reported from Keokuk 1891. Lawler, 1891 (P. H. Rolfs). Missouri Valley, 1894. Ontario, 1890. Sioux City, 1872. Ames, 1895 (G. W. Carver). Boone, 1870. Charles City, 1876 (J. C. Arthur). Woodbine, 1894. Vale, 1894. Boone, 1890 and 1894. Turin, 1894. Onawa, 1894. Carroll, 1894. Humboldt (F. L. Harvey). It will not be many years until this weed is as common in western part of Iowa as *Ambrosia trifida*; originally a plant of northern and western Iowa, from whence it has spread east and south.

Eclipta alba Hassk. Keokuk, 1877 (George E. Ehinger). 1891 (P. H. Rolfs).

Lepachys columnaris Torr. & Gray. Boone, 1889. In 1896 it was found by George W. Carver.

Helianthus annuus L. Ames and other parts in central Iowa occasional, but in western Iowa indigenous and very abundant, becoming frequent as far as Carroll, Denison and Boone. Ames, 1882. It is scarcely abundant except in a few localities in central Iowa. I am inclined to think it is an introduced plant with us. Boone, 1871 (C. E. Bessey). Grinnell, 1891 (M. E. Jones). Keokuk, 1891 (P. H. Rolfs). Muscatine, 1891 (Reppert). Marshalltown, 1891 (F. C. Stewart).

Helianthus maximiliani Schrad. Indigenous to northern and western Iowa, confined originally in western part of the state to the loess hills and adjoining bottoms, but now occurs along some of the great trunk lines extending across the state. A small patch has persisted at Ames for several years. 1894 (G. W. Carver).

Gaillardia aristata Pursh. This western plant has been found at Ames, 1896 (G. W. Carver). Too soon to say whether it will become naturalized.

Dysodia chrysanthemoides Lag. Boone, 1890. Ackley, 1878 (B. E. Canavan). Keokuk, 1891 (P. H. Rolfs). Muscatine, 1891 (F. Reppert). This striking weed has been known for some time at Ames, though said to be frequent by Hitchcock (Anth. *Pteridophyta* of Ames, p. 503). It is more or less periodic in its appearance, some years frequent, others it is not so common. It is, however, always abundant in western and southwestern Iowa, which leads me to believe that the plant is not indigenous to central Iowa, but introduced, although now occurring in timber and along river banks.

Anthemis cotula D. C. This European weed is by no means as common in dooryards, along roadsides and in streets as in Wisconsin, Illinois and Minnesota. It shows evidence, however, of being widely distributed in the state, and early introduced.

Chrysanthemum leucanthemum L. For a long period of years occasional specimens of this weed have been found in the vicinity of the college, and it is an occasional introduction in meadows, but except in one place some four miles from Ames it shows no evidence of being naturalized. It has also been reported from Muscatine (Reppert). Atlantic (S. O. Hamill). Ames, 1871 (C. E. Bessey). Ames, 1891 (P. H. Rolfs). Sheldahl, 1885 (L. V. Harpel). Ackley, 1878, (B. E. Canavan).

Tanacetum vulgare L. Although escaped here and there from gardens there are but few places where it is naturalized.

Cnicus lanceolatus Hoffm. This is a frequent weed, especially eastern, southern, northern, western and central portions of the

state, and found as an occasional plant in every part of the state, especially in pastures where timber has been cut. It shows evidence of having been introduced a long time. Boone, 1890. Lawler, 1890. Keokuk, 1891 (P. H. Rolfs). Muscatine, 1891 (F. Reppert). Iowa City (A. S. Hitchcock).

C. altissimus Willd., var. *filipendulus* Gray. Indigenous in Western Iowa, loess hills, is spreading to cultivated fields eastward. Reported from Ruthven (Daniel Chaffie). Atlantic, 1895. Marcus, 1895 (N. E. Willey).

C. arvensis Hoffm. Widely distributed in the state, but generally confined to small areas. It is reported more frequently than any other *Onicus*, though the least common of our species, it is interesting to record the fact that occasionally seed is produced. Lawler, 1890 (P. H. Rolfs). Greenfield, 1891 (F. C. Stewart). Marcus, 1896 (Willey). Winterset, 1896. Corning, 1895 (A. B. Shaw). 1896 (Chas. B. Collman). Chase, Johnson county, 1874 (O. G. Babcock). Taylor, 1895 (J. B. Matthews). Maple River Junction, 1895 (L. Bernholtz). Far-ragut, 1895 (C. Collman). Randall (C. and G. P. Christianson). Redding (Dr. W. A. McClanahan). Griswold (R. E. Pierce). Conrad Grove, Cresco, 1892, with "seed" (C. V. Johnson). Oelwein (J. Thompson). Chickasaw county (P. H. Rolfs). Muscatine (F. Reppert). Barnes City, 1896 (J. W. Jones).

Cichorium intybus L. Corning, 1895 (Ellen Bettonier). Midway, well established, 1896. Des Moines, 1895.

Tragopogon porrifolius L. Ames, 1896 (C. R. Ball).

T. pratensis L. Ames, in meadow, 1894. Iowa City, 1889, Newton, 1889 (A. S. Hitchcock).

Hieracium aurantiacum L. Ames, 1894, meadows, not established.

Lygodesmia juncea Don. Indigenous only to western and northwestern part of the state, becoming a bad weed in northwestern Iowa. (C. R. Ball.) Armstrong (R. I. Cratty). Most abundant on loess hills; has appeared at Carroll, 1895, Logan, and other points along the C. & N.-W. R. R.

Lactuca scariola L. Abundant everywhere in Iowa except northwestern and possibly northeastern. Marshalltown, 1891 (F. C. Stewart). Ames, 1889 (A. S. Hitchcock). Muscatine, 1891 (F. Reppert).

L. pulchella DC. Indigenous to loess hills of western Iowa. Has become abundant along roadsides and streets in Sioux City. Showing tendency to spread. Ames, 1887, 1889 (A. S.

Hitchcock). Fremont county (A. S. Hitchcock). Sioux City, Council Bluffs, Keokuk, 1891 (P. H. Rolfs).

BORRAGINACEÆ.

Echium vulgare L. Ames, 1894 (G. W. Carver). Not since observed.

CONVOLVULACEÆ.

Convolvulus arvensis. Ames. Since 1887 well established. Ladora, 1895 (John Hiltbrummer). Des Moines, 1896 (C. N. Page). Very likely occurs in other places. First introduced as a cultivated plant. This may become one of our most pestiferous of perennial weeds.

SOLANACEÆ.

Solanum carolinense L. This weed has been well established on the college farm since 1887. As it started in an experimental plot, I am inclined to think it was introduced accidentally with some cultivated plants. It has been reported to me from many other places in the state. Certainly showing an extension northward and that acclimation has occurred.

The following are the localities for this state:

Zearing, 1896 (J. S. Bartley). Indianola, 1895 (A. D. Field). Mapleton, 1895 (Abjh. Lamb). Story City (C. C. Johnson). Central City, 1894 (Herman Finson). Fayette, 1894 (Mrs. M. E. Williams). Logan, 1895, Council Bluffs, 1895. (L. H. P.) Professor Bessey informs me that he observed it here many years ago. It is well established at this point. Ogden, 1894 (John Williams). Plattsville, 1894 (J. B. Studley). Des Moines, 1894. Woodbine (Erastus Childs, Geo. Phillips). Muscatine (F. Repert). Keokuk, 1891 (P. H. Rolfs). Taylor county, 1894 (C. O. Pool). Grand Junction, 1890.

Solanum rostratum Dunal. This weed has been reported from many widely scattered localities. It was not common in 1887 or up to 1890, since Professor Hitchcock, a diligent collector, does not report it in catalogue of the Anthophyta and Pteridophyta of Ames, Iowa, 1891. It has been long known in western Iowa, as Professor Todd informs me. Ames, 1895 (John Arrasmith, Turner McClain). Montezuma, 1895 (J. M. Bryan). Aspinwall, 1895 (C. H. Laughlin). Woodbine, 1895 (R. B. Boustead). New Hartford, 1895 (J. W. P). Maple Grove, 1895 (Mitchell). Gilmore City, 1895 (Van Alstine). Rowley, 1895 (J. G. E. McDonald). Creston, 1895 (Mrs. Mary A. McClure). I observed it common in the streets at this place in

1894. Newell 1894, Corning, 1894, Ainsworth, 1894, Perlee, 1894 (D. M. Carty). Ladora, 1896 (Whitlock and Fields). Emmetsburg, 1896 (McCarty and Lindermann). New London, 1895. Guthrie Center (W. M. Ashton). Whitmore, 1894 (J. E. Albin). Morrison, 1894 (A. E. Allen). Elliott, 1895 (Adam Lentz). Renwick, 1895 (Bell and Thiel). Dysart (Emma Sirrine). Des Moines, Carson (J. A. Bass). Perry, 1895 (Geo. O. Roberts). Gilmore City, 1895 (D. Van Alstine). Hamburg, 1888 (A. S. Hitchcock). Agency, 1887 (Mrs. Richman). Council Bluffs, 1883. Mt. Ayr, 1894 (J. W. Sale). Carroll county, Des Moines fair grounds (A. G. Lucas).

Solanum Torreyi Gray. Southern Iowa, 1895.

SCROPHULARIACEÆ.

Verbascum Thapsus L. This weed is common in eastern, central and southern Iowa. Probably early introduced. It is not, however, spreading rapidly.

V. Blattaria L. Ames, 1889 (Hitchcock). And several times since (F. A. Sirrine). Not, however, a permanent weed. Muscatine, 1890 (F. Reppert).

Linaria, vulgaris Mill. Ames. I am unable to learn when first introduced. Well established.

LABIATÆ.

Salvia lanceolata Willd. Indigenous to western Iowa. Council Bluffs, Fremont county, Missouri Valley, Ames, 1890 (F. A. Sirrine). Des Moines, 1895. Well established. Muscatine, 1890 (F. Reppert).

PLANTAGINACEÆ.

Plantago lanceolata L. Ames, 1874 (C. E. Peterson). Well established in fields. Milton (J. C. Holland).

CHENOPODIACEÆ

Cycloloma platyphyllum Moquin. Not indigenous in Iowa. Cedar Rapids, Des Moines, 1894 (G. W. Carver). Muscatine, 1890. Des Moines, 1887 (A. S. Hitchcock). Hamburg (A. S. Hitchcock).

Chenopodium urbicum L. Nevada, 1880 (A. S. Hitchcock). Iowa City 1887 (A. S. Hitchcock). Keokuk, 1887 (A. S. Hitchcock). Ames, 1891 (A. S. Hitchcock). Muscatine, 1889, Davenport, 1889 (A. S. Hitchcock). Muscatine, 1890 (F. Reppert). Keokuk, 1891 (P. H. Rolfs).

C. glaucum L. Iowa City, 1839 (Hitchcock). Muscatine (F. Reppert).

C. Botrys L. Ames, 1883; Iowa City, 1887 (A. S. Hitchcock).

C. ambrosioides L. Keokuk (J. C. Arthur). Muscatine, 1876 (Burgess.) Muscatine 1890 (F. Reppert).

C. Rubrum. Keokuk, P. H. Rolfs, 1891.

Atriplex patulum L., var. *hastatum* Gray. Keokuk, 1891 (P. H. Rolfs). Ames, 1896 6. It has become well established. Iowa City, 1887 (A. S. Hitchcock). Var. *littorale*. Iowa City, 1887 (A. S. Hitchcock).

A. argenteum Nutt. Ames, 1895 G. W. Carver).

PHYTOLACCACEÆ.

Phytolacca decandra L. Grinnell, 1889 (A. S. Hitchcock). Muscatine, 1891 (F. Reppert).

POLYGONACEÆ.

Rumex Patieutia L. Boone (G. W. Carver). Established. Escaped from cultivation.

Polygonum orientale L. Muscatine, 1890 (F. Reppert). Onawa, 1894.

EUPHORBIACEÆ.

Euphorbia marginata Push. Indigenous to western Iowa. Little Rock, Sioux City, Onawa, Council Bluffs and Hawarden. Naturalized east. At Denison abundant, 1894. Woodbine, 1894. Vale, abundant, 1894. Missouri Valley, Carroll, 1895, abundant (W. Newell). Hamburg, 1883 (A. S. Hitchcock). Iowa City, 1887 (A. S. Hitchcock).

A STUDY OF THE LEAF ANATOMY OF SOME SPECIES OF THE GENUS BROMUS.

EMMA SIRRINE.

The species of genus *Bromus* are sometimes difficult to differentiate; hence, a study of the leaf anatomy was undertaken with a view towards a help in differentiation.

BROMUS ASPERT.*

(Pl. v. Fig. 5; Pl. vii, Fig. 8.)

Epidermis.—The cuticle in this species is quite thick. The epidermal cells are large, but are smaller and thicker walled above and beneath the primary mestome bundles than elsewhere. Stomata frequently occur on both surfaces. The upper and lower surfaces of leaf, as well as edges, are provided with trichomes, sometimes in the form of small conical projections.

Bulliform cells.—These occur on superior surface, and vary in number from three to five, and are not as thick walled as the epidermal cells. They occur between the mestome bundles, but this arrangement is not uniform, that is, they are not present between all mestome bundles.

Mestome bundles.—Twenty-nine mestome bundles occur across middle portion of leaf. The bundles are of three types: First, the primary type numbers eleven bundles. These open on both superior and inferior surfaces of leaf, *i. e.*, the leptome and hadrome are in direct contact with the stereome or separated from it only by colorless parenchyma cells; they vary in size (from the midrib to the margins of leaf); the one of the midrib is the largest. Bundles of the secondary type number seventeen. These are entirely closed, *i. e.*, chlorophyll bearing

*This was determined later as *Bromus patulus*. M. & K., by F. Lamson-Scribner.

There is an apparent repetition in papers by Miss Sirrime and Miss Pammel, in fact the same species were studied. They appeared distinct, but Professor Lamson-Scribner determined them as above.

L. H. PAMMEL.

parenchyma enclose the leptome and hadrome. They alternate with the primary bundles, except at the margins of the leaf, when three occur in succession on one side of the large primary bundle in the carene. Two of the secondary bundles are present; on the opposite side of the primary bundle in the carene, a bundle occurs which is intermediate between the primary and secondary bundles; this intermediate bundle is open inferiorly only, *i. e.*, the leptome only is in contact with the stereome. This is the only bundle of this type found in this species, but it was constant in all the *asper* sections examined. The primary bundles are enclosed by thick-walled cells, the mestome sheath; outside of this is a row of thinner-walled cells, the parenchyma sheath. In the bundles of the secondary and intermediate types, the mestome sheath occurs, while the parenchyma sheath disappears.

Carene.—The carene consists of only one bundle, which is the primary type; this conforms to the description given to others of this kind, except that it is the largest bundle. The hadrome is separated from the stereome by colorless parenchyma cells, while a single row of thick walled cells, resembling stereome, separates the leptome from the hadrome. Two large pitted ducts and two spiral ducts with an intercellular space are present. The bundle is enclosed by mestome and parenchyma sheaths. Trichomes in the shape of conical projections occur on the inferior surface of leaf above the primary mestome bundle. To one side of this a secondary bundle occurs, with pitted and spiral ducts. On the opposite side of the primary bundle the intermediate bundle occurs. This is open inferiorly only. The leptome is in contact with the stereome by means of two rows of colorless parenchyma cells, while the mestome sheath surrounds the mesophyll. In other respects it is the same as the secondary bundle.

Stereome.—Stereome occurs both on superior and inferior surfaces of the primary bundles. None is present in the bundles of the secondary type and only a very little on the inferior side of the intermediate bundle. Stereome occurs in groups of from four to six cells on the margins of the leaf. The walls of the stereome are frequently stratified.

Colorless parenchyma is found beneath all the primary bundles; it fills the space between the hadrome and the stereome, while a single row of cells enclose the whole mestome bundles. In the bundles of the secondary type it disappears entirely.

Mesophyll.—This surrounds the bundles of the secondary type and occurs between all bundles. It is made up of irregular cells, but quite uniform in size. The chlorophyll granules are quite large and numerous.

BROMUS PATULUS, M. & K.

(Pl. v., Fig. 3; Pl. vi. Fig. 6.)

This is a small early form determined as *B. nivilis*.

Epidermis.—The epidermal cells of this species are large, regular, thick-walled with a strong, well developed cuticle; the cells above and beneath the carene are smaller and thicker than elsewhere; the leaf is more involute than that of any other species studied, unless possibly *Bromus racemosus*. Trichomes are numerous,—some very long and slender, others are short and thick. Stomata occur on both surfaces of the leaf.

Bulliform cells.—The bulliform cells vary in number from three to five, and are not as apparent as in some of the other species studied. These cells occur on superior surface of leaf between the mestome bundles.

Mestome bundles.—These number from twenty-five to thirty and are of two kinds. The bundles of the primary type number from nine to eleven, represented by the principal bundle of the carene. This is open both to the upper and lower surfaces of the leaf, *i. e.*, the leptome is in direct contact with the stereome, while the hadrome is separated from it only by colorless parenchyma cells. The secondary bundles number from sixteen to eighteen. The leptome and hadrome are entirely surrounded by chlorophyll-bearing parenchyma. In the largest bundle of the primary type the stereome is very abundant, while in the smaller ones, it is reduced in some instances to a single row of cells; the leptome and hadrome are well developed in these bundles and they are separated from each other by thick-walled cells resembling stereome. Both spiral and pitted ducts, as well as the intercellular space, are well defined. The secondary bundles are surrounded by colorless parenchyma without stereome. The leptome and hadrome are differentiated. Two secondary bundles occur on margins of leaf.

Carene.—The carene consists of one typical primary bundle with leptome and hadrome well developed and separated from each other by thick-walled parenchyma cells; the pitted and spiral ducts are well developed and also the intercellular space is conspicuous. On one side of this bundle is another primary

bundle, smaller than the mid-bundle but open superiorly and inferiorly, *i. e.*, the leptome and hadrome are in contact with the stereome, but this bundle differs from the first described, in that it has inferiorly only a single row of stereome running from the bundle to the epidermal cells, while in the first one there is a large amount of stereome on inferior surface. The stereome beneath this second bundle conforms with that found in the other primary bundles of this species. All these primary bundles are surrounded by two sheaths: an outer, thin-walled colorless row of cells, the parenchyma sheath and inside this a thick-walled row of cells, sometimes incomplete, the mestome sheath. The bundle on the other side of the central bundle is one of the secondary type. No stereome occurs in connection with these bundles; they are entirely closed, that is, wholly surrounded by chlorophyll-bearing parenchyma. These bundles are enclosed by a mestome sheath but the parenchyma sheath is absent. The leptome and hadrome fill the entire space inside the mestome sheath unless possibly a few thick-walled cells between them.

Stereome.—This occurs only above and below the primary bundles, and on the margins of the leaf.

Colorless parenchyma occurs below the stereome of all primary bundles, and forms a sheath for the whole primary mestome bundle.

Mesophyll.—This surrounds not only the secondary bundles but occurs between all the primary and secondary bundles.

BROMUS INERMIS.

(Pl. v, Fig. 4; Pl. vii, Fig. 10.)

Epidermis.—In this species we find large, regular, and well developed epidermal cells with a thick cuticle; the cells are smaller and the cuticle thicker under and above the mestome bundles than elsewhere. The epidermal cells are slightly longer on superior surface of leaf than on inferior surface. Trichomes absent. Stomata occur on both surfaces of leaf, but especially between the bulliform cells.

Bulliform cells.—These are large, varying in number from three to seven, only present on superior surface of the leaf.

Mestome bundles.—These number thirty-five, and are of three types, as in some specimens of *Bromus asper*. First, those of the primary type; these are open both on anterior and inferior surfaces of the leaf, *i. e.*, the leptome is in direct contact with the stereome and the hadrome, separated from it only by

colorless parenchyma cells. These primary bundles are enclosed by the parenchyma and mestome sheaths. Those of the secondary type are entirely closed and surrounded by chlorophyll-bearing parenchyma. Third is an intermediate type, open only inferiorly; the leptome is in contact with the stereome, while the hadrome is surrounded by chlorophyll-bearing parenchyma cells. These intermediate bundles occur in only two places in the leaf,—one is found in the carene and one at the margin of the leaf.

Carene.—The carene consists of one mestome bundle. A large bundle open above and below, *i. e.*, the leptome and hadrome are in contact with the stereome. The pitted ducts are irregular. The stereome is more abundant above than below the bundle. This is true of all the open bundles in this species; the leptome is separated from the hadrome by a layer of thick-walled parenchyma cells, while the whole bundle is enclosed in both parenchyma and mestome sheaths. On one side of this primary bundle a secondary bundle occurs; this is entirely closed by chlorophyll-bearing parenchyma cells. Leptome and hadrome are present with a few thick-walled cells between them, and the whole enclosed by a mestome sheath. On the opposite side of the primary bundles is one of the intermediate type.

Stereome.—This occurs on the margin of leaf above and below the primary bundles, and above the intermediate bundles.

Colorless parenchyma is more or less developed below all the bundles of the primary type.

Mesophyll is found between all bundles, surrounding the secondary and below the intermediate bundles. It consists of elongated cells filled with chlorophyll.

BROMUS SECALINUS.

(Pl. vi, Fig. 2; Pl. viii, Fig. 9.)

Epidermis.—In this species, the epidermal cells are large and regular on inferior surface with an occasional cell projecting outwardly. On the superior surface of the leaf the cells are somewhat smaller and of same general shape. The leaf is somewhat involute. Small trichomes in the shape of conical projections are present on the inferior surface of the mestome bundles. Epidermal cells are smaller where it covers the primary mestome bundles in this species, as in all studied. Stomata present on both surfaces.

Bulliform cells.—These occur only on superior surface of leaf and vary in number from three to seven. These cells are large and well marked, especially the central cells of the group; the outer are smaller and blend with the epidermal cells. The cuticle is not so strongly developed over the bulliform cells as elsewhere.

Mestome bundles.—These number from thirty-three to thirty-five and are of three types. First, primary, in which superior and inferior surfaces of leaf are open, *i. e.*, the leptome is in direct contact with the stereome and the hadrome separated from it only by the uncolored parenchyma cells. From thirteen to fifteen of these bundles are present, varying in size from the carene to the tip of leaf. In the secondary type, leptome and hadrome are entirely surrounded by chlorophyll parenchyma. The bundles in this type number from fifteen to seventeen; they alternate regularly with those of the primary type except between the sixth or seventh primary bundles counting from the mid-rib where two of the secondary type occur in succession. Only two bundles of the intermediate type occur. These are found near the margins of the leaf. They have leptome in contact with stereome only. Surrounding all the bundles occur both parenchyma and mestome sheaths.

Carene.—Only one bundle present in the carene. It is of the first type and is remarkable for the large amount of stereome on the superior surface of leaf. The leptome and hadrome are separated from each other by two rows of thick-walled parenchyma cells. The leptome is separated from stereome only by the parenchyma and mestome sheaths, while the hadrome is separated from the stereome by a large number of colorless parenchyma cells. On either side of the carene, the small secondary bundles occur. In these the leptome and hadrome seem to be in direct contact with each other. Both sheaths are present.

Stereome.—No stereome occurs around the secondary bundles. It is abundant on superior and inferior surfaces of the primary type and on superior surface of the intermediate bundles. A group of these cells also on margins of leaf. Stereome cells are marked with small canals.

Colorless parenchyma.—This occurs beneath all primary bundles, while a sheath encloses all the bundles.

Mesophyll.—This surrounds all the secondary bundles and occurs between the other two types, and on inferior portion of the intermediate type.

Fig. 1.

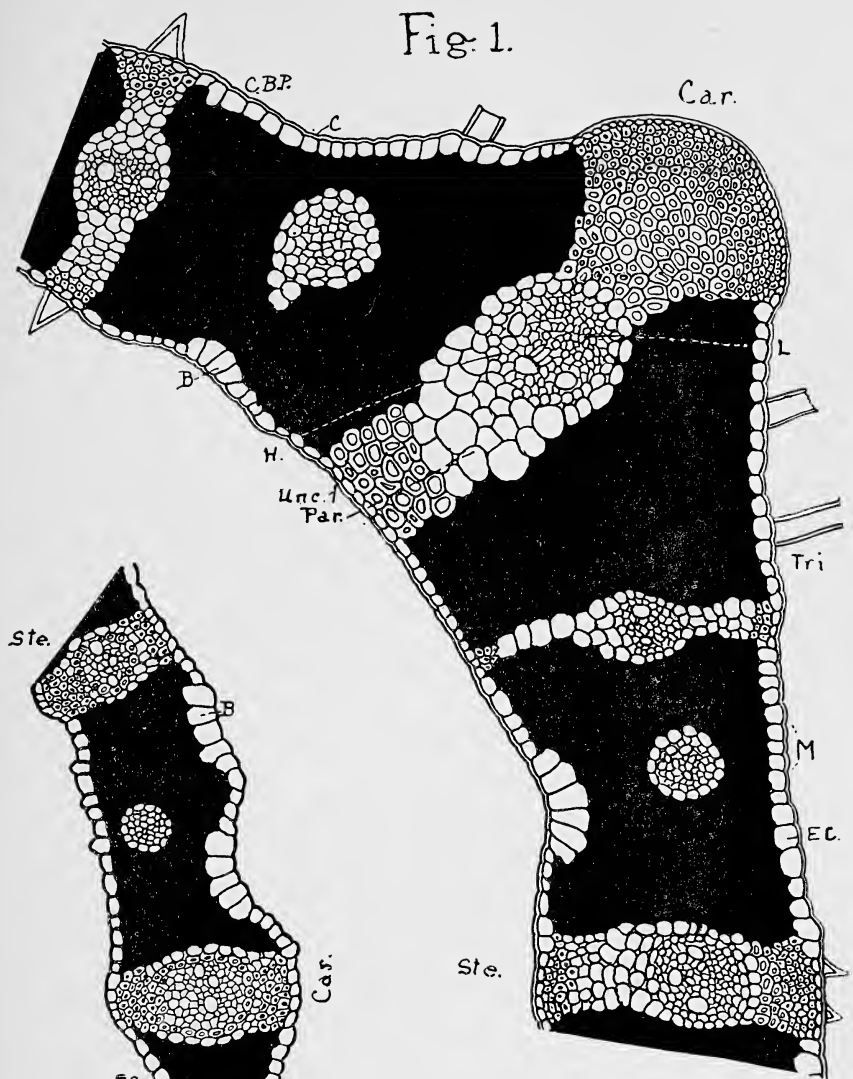


Fig 2.

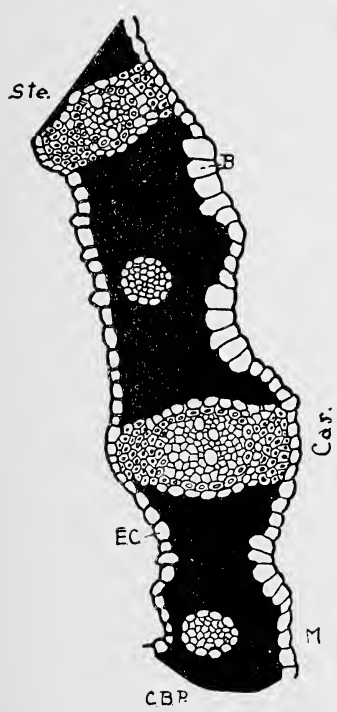


Fig. 3.

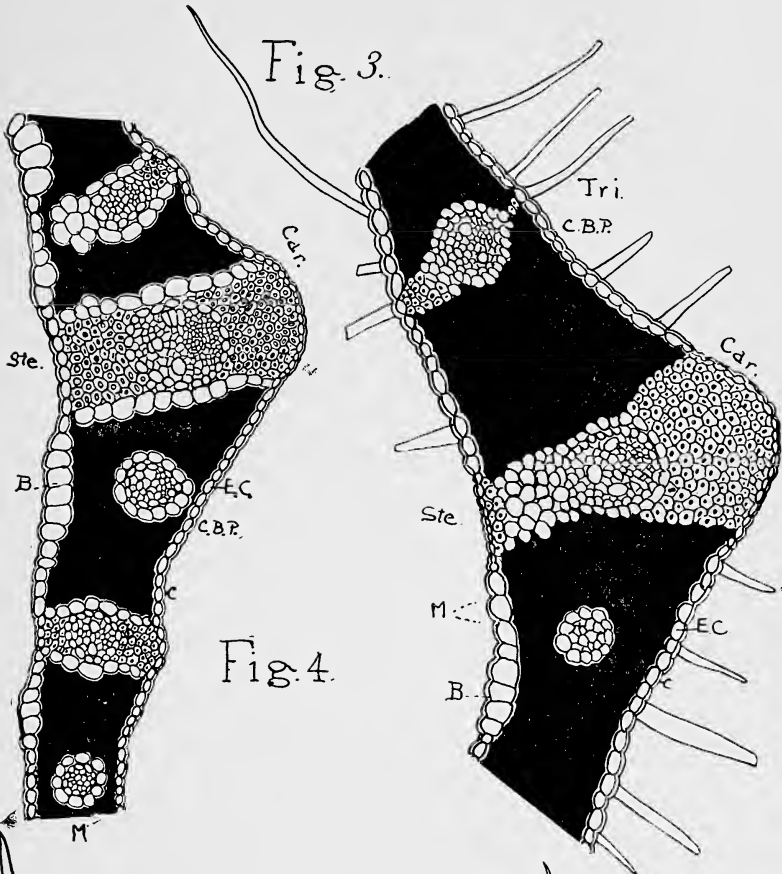


Fig. 4.

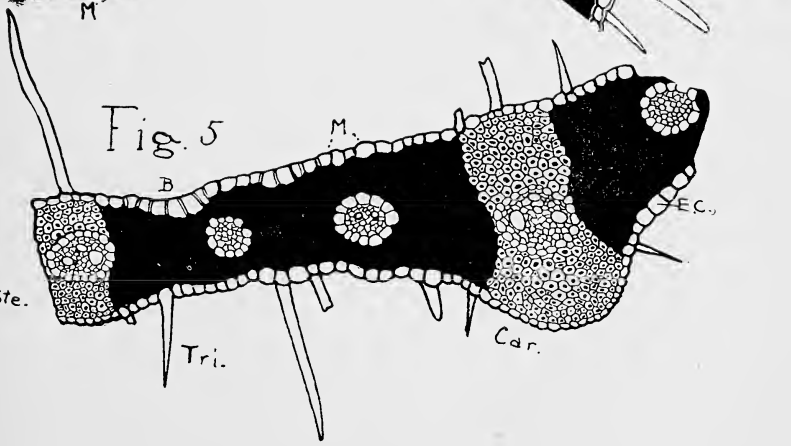
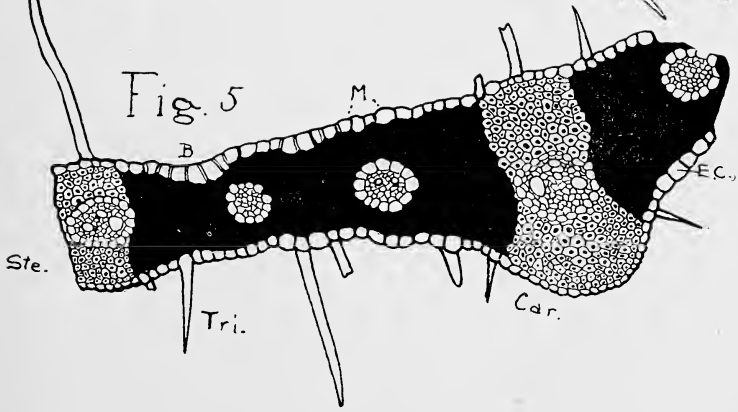
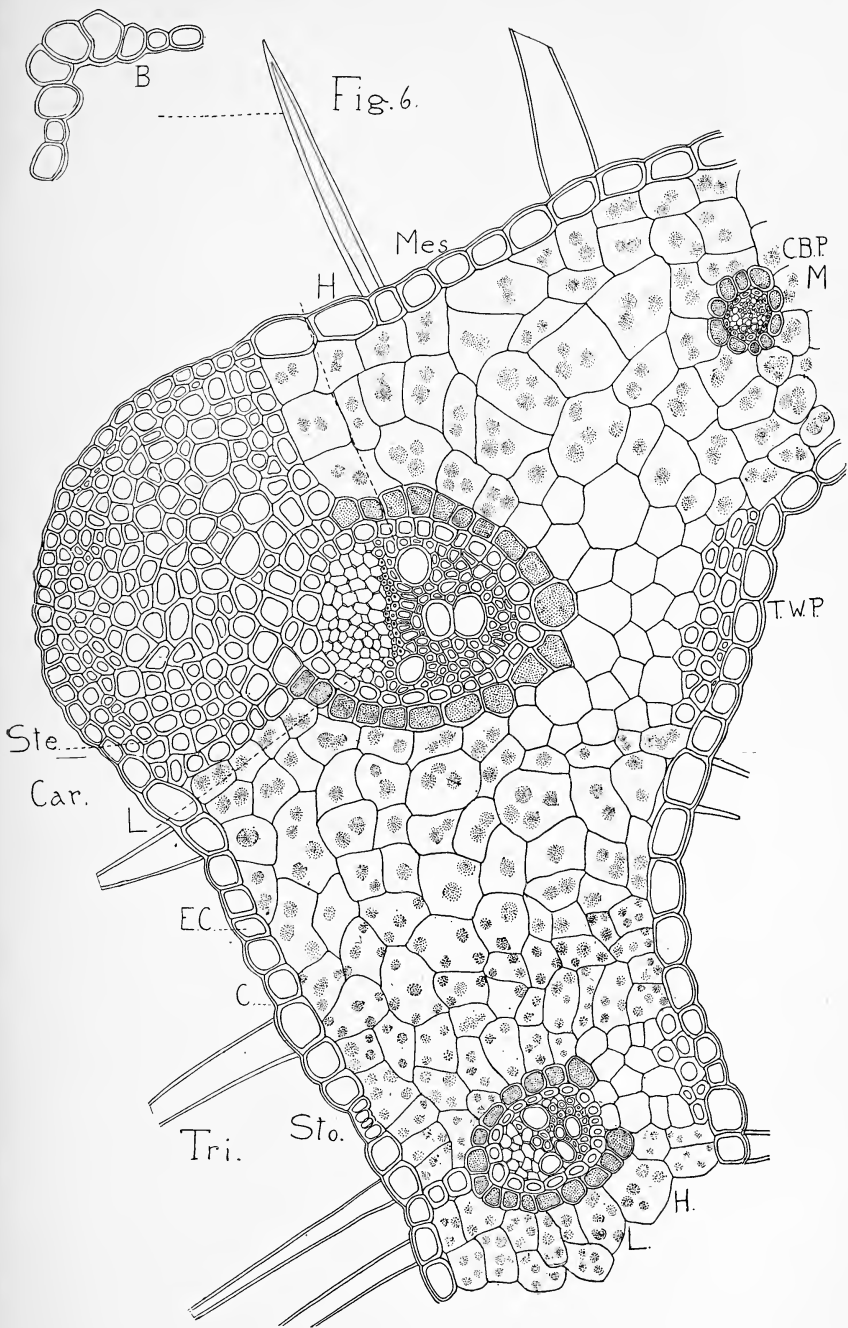
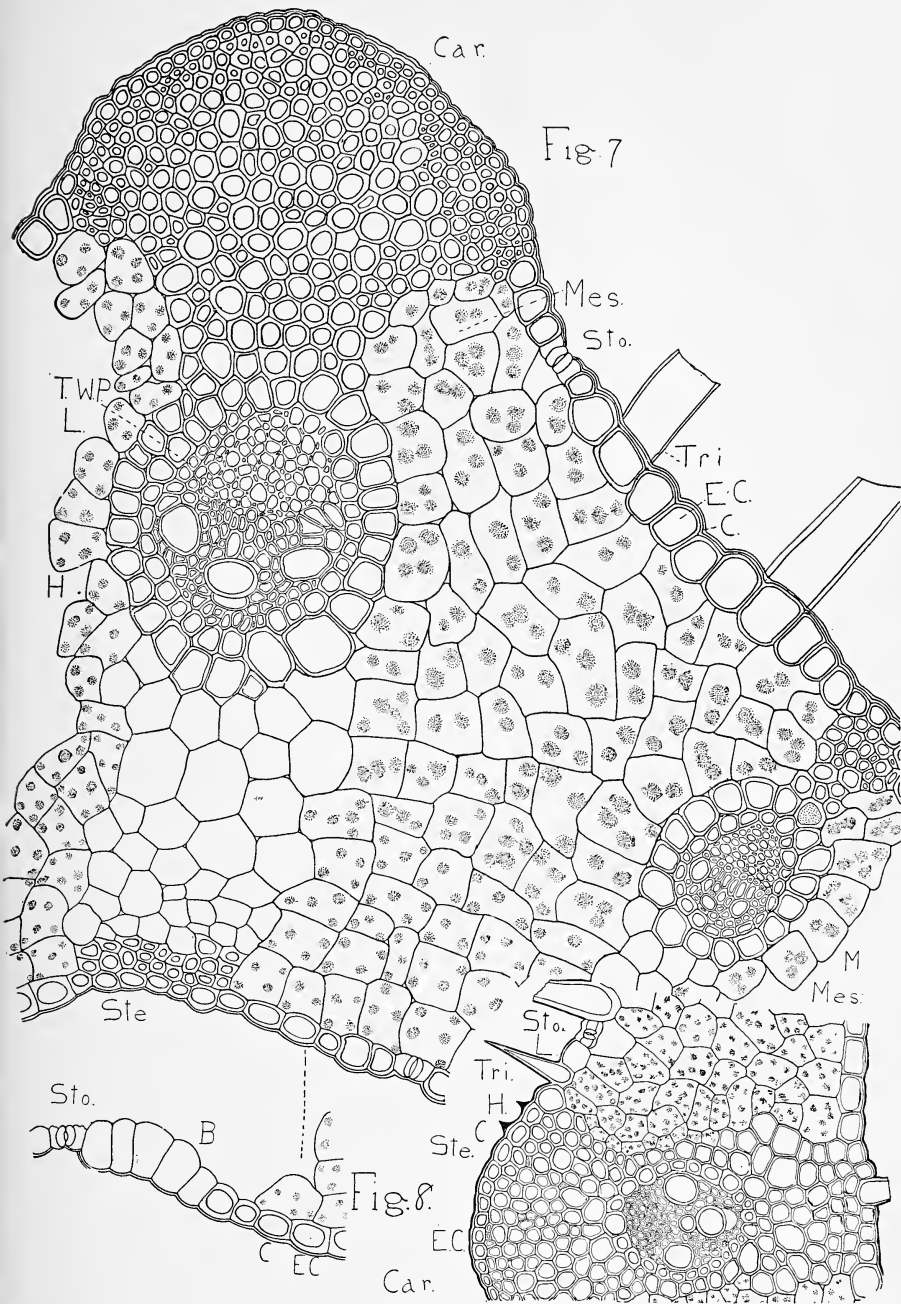


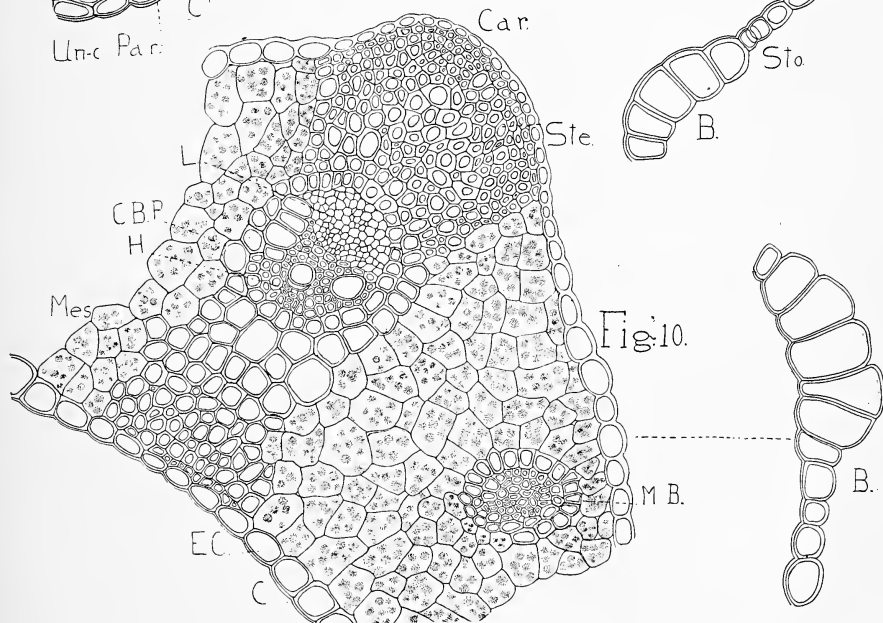
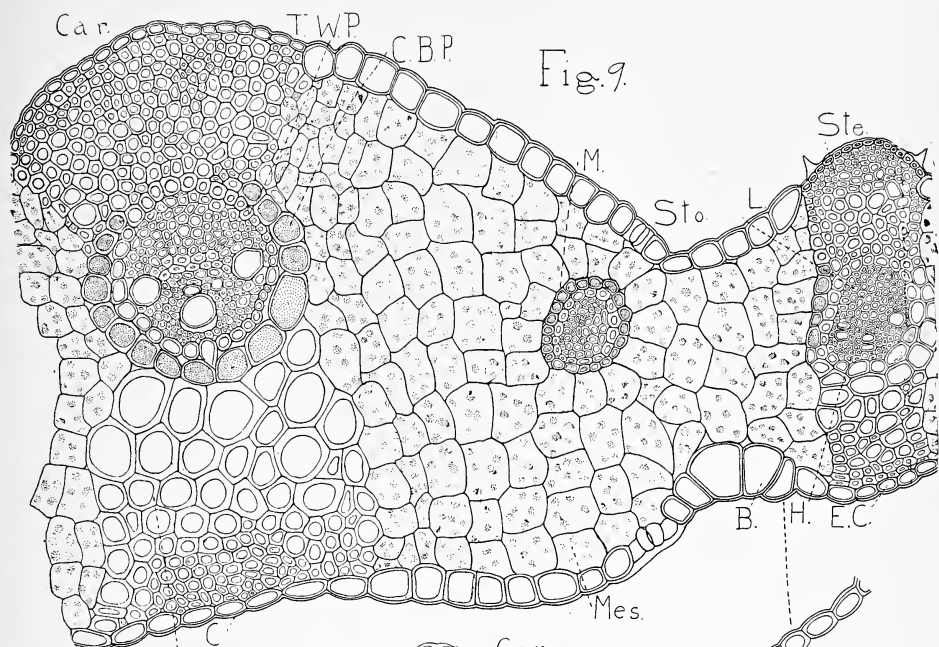
Fig. 5.











BROMUS BREVIARISTATUS.

(Pl. iv, Fig. 1; Pl. vii, Fig. 7.)

Epidermis.—The epidermal cells are large and nearly rectangular, with a thick cuticle. The cells are a trifle smaller on inferior surface of leaf than on anterior, while on superior and inferior surfaces of mestome bundles they are much smaller than elsewhere. Conical projections occur both anteriorly and inferiorly on primary mestome bundles. Stomata are present on both surfaces, while trichomes are long and quite abundant.

Bulliform cells.—The bulliform cells are large and vary in number from three to six.

Mestome bundles.—Forty-one bundles present, of two types. Those of the primary type are open on both inferior and superior surfaces, *i. e.*, leptome is in direct contact with stereome, while hadrome is separated from it only by colorless parenchyma. These primary bundles vary much in size, and also in the amount of stereome and colorless parenchyma. The secondary bundles are somewhat better developed in this species than in other species studied, in that both mestome and parenchyma sheaths are present, also spiral and pitted ducts. There is an indication of an intermediate bundle at the margin of the leaf.

Carene.—Carene consists of only one bundle, and with the exception of size, the large amount of stereome and colorless parenchyma is exactly the same as those in the other species.

Colorless parenchyma.—The colorless parenchyma occurs beneath all primary bundles, while a sheath encloses all the bundles.

Stereome.—This is abundant on both inferior and superior surfaces of the primary type of bundles and on superior surface of the intermediate bundles.

Mesophyll.—This surrounds all the secondary bundles and occurs between the other two types, and on the inferior portion of the intermediate type.

EXPLANATION OF PLATES.

All drawings made with a camera and drawn to the same scale. The abbreviations used are: C., cuticle; E., epidermis; E. C., epidermal cells; Sto., stomata; Tr., trichomes; B. C., bulliform cells; Ste., stereome; Mes., mesophyll; C. B. P., chlorophyll-bearing parenchyma; Car., carene; M. B., mestome bundles; H., hadrome; L., leptome; Unc. Par., uncolored parenchyma; T. W. P., thick-walled parenchyma.

PLATE iv, Fig. 1, *Bromus breviaristatus*. Fig. 2, *Bromus secalinus*.

PLATE v., Fig. 3, *Bromus patulus*. Fig. 4, *Bromus inermis*. Fig. 5, *Bromus asper*.

PLATE vi, Fig. 6, *Bromus patulus*.

PLATE vii, Fig. 7, *Bromus breviaristatus*. Fig. 8, *Bromus asper*.

PLATE viii, Fig. 9, *Bromus secalinus*. Fig. 10, *Bromus inermis*.

A COMPARATIVE STUDY OF THE LEAVES OF LOLIUM, FESTUCA, AND BROMUS.

BY EMMA PAMMEL.

There are some striking differences in the leaves of *Festuca* and *Lolium*. One of the most essential in the species studied is the presence or absence of hairs and the involute character of the leaf of *Festuca tenella*.

LOLIUM PERENNE.

(Pl. ix, Fig. 3; Pl. xi, Fig. 8.)

Epidermis.—The cuticle is quite strongly developed on superior and inferior surfaces of the leaf, but more so on the inferior surface. The epidermal cells are rather large, but vary some in size; the largest occur on inferior surface of leaf and are nearly as large as the bulliform cells. The smallest epidermal cells occur chiefly at the tip of leaf. The epidermal cells above and below the stereome are smaller and are strongly thickened.

Bulliform cells.—The conspicuous bulliform cells number from four to five. The central are large and one or two on either side occur between each mestome bundle. The epidermal cells on the inferior surface of leaf are more uniform in size.

Mestome bundles.—These number eighteen, of three types. Primary bundles, those which are open on superior side of leaf, *i. e.*, where hadrome is either in direct contact with stereome or separated from it by colorless parenchyma cells, and secondary bundles or such as are closed, *i. e.*, the leptome and hadrome entirely surrounded by chlorophyll-bearing parenchyma; and third the intermediate type. The secondary mestome bundles are more numerous. The leptome and hadrome of the mestome bundle of carene are well developed. The mestome bundle of carene is of the primary type with well developed pitted vessels and spiral ducts. Two rows of thick-walled cells separate hadrome and leptome. The hadrome is separated from the

stereome by several rows of thin-walled parenchyma cells. The stereome is more strongly developed on the inferior surface of mestome bundles of carene than on superior surface of bundle. In carene the stereome is not in contact with leptome.

A thin-walled parenchyma sheath surrounds the entire bundles of secondary type. Thick-walled cells occur on the inside of this parenchyma sheath, which thus forms a sheath around the leptome and hadrome.

Two kinds of mestome bundles of secondary type occur, one in which leptome and hadrome are perfectly developed, and a second in which leptome and hadrome are not so strongly marked. Those of the second type alternate with the large bundles. These bundles are surrounded by a chlorophyll-bearing parenchyma sheath. To the inside of this sheath is a second sheath which consists of thick-walled cells (mestome sheath) surrounding the leptome and hadrome, and hence is closed. The mestome bundles of intermediate type are four in number, and do not vary from the mestome bundle of primary type except that they are closed, and there are only two pitted vessels.

Stereome.—The stereome is found on margin of leaf on superior surface of all bundles of intermediate and primary types, and on the inferior surface of some of the mestome bundles of secondary type.

Mesophyll.—This occurs between the mestome bundles, and is in contact with the epidermis on both faces. The cells are irregular, some are nearly round, others are oblong. The chlorophyll grains are large. The cells of the mesophyll on margins of leaf are somewhat smaller than in other parts.

FESTUCA.

Two species of *Festuca* were studied. *Festuca elatior*, variety *pratensis*, and *Festuca tenella*.

Beal quotes Hackel's statement as to the different forms of *Festuca*: "Hackel finds the mesophyll and fibro vascular bundles quite uniform with all sorts of treatment of the plants, but the epidermis offers remarkable differences, especially that on lower surface of leaf. This difference is apparent in the thickness of the outer walls, the size of the cavities, and the existence or absence of projections on the partition walls. The dry cultivated plants had their epidermis strongly thickened toward the outside, the cavities diminished and over the partition wall

had developed cuticular projections. The moist cultivated plants produced slightly thickened epidermal cells, broad cavities, and no trace of cuticular projections. The sclerenchyma, or bast, varies much with different soils and amounts of moisture. Species of moist, shady habitats, show in their leaves a clear preponderance of the assimilating over the mechanical system."

These views coincide with the observation made in a study of the species here considered.

FESTUCA ELATIOR, VAR. PRATENSIS.

(Pl. ix, Fig. 1; Pl. xi, Fig. 9.)

Epidermis.—The epidermis is quite strongly developed in this species; the cuticle is more strongly developed on the inferior than superior surface. Small conical projections occur only on the superior surface of leaf. These are not very numerous. They are most numerous near the carene. The epidermal cells are quite uniform in shape; some variations occur, mostly on the superior surface. The cells of epidermis over the stereome on both superior and inferior surfaces are strongly thickened and are smaller than the unthickened epidermal cells.

Bulliform cells.—The bulliform cells are similar in size to those found in *Lolium perenne*. They are five in number, three large cells in center and one smaller one on either side. These are much more strongly developed toward the middle of leaf than on the margin. On approaching the margin of the leaf the bulliform cells can hardly be distinguished from ordinary epidermal cells.

Mestome bundles.—The number of mestome bundles in a single cross section in middle of leaf is twenty-four, and are not so close as in *Lolium*. There are three types. First, primary type, open on inferior and superior sides. Secondary type, those that are entirely closed, and these are most numerous. Third, the intermediate type, which are open only on superior side. The bundles of secondary type are most numerous. Three of the closed bundles occur near the margin of leaf. One bundle of the primary type is found next to the closed bundles. The third type is found to the left of mestome bundle of carene, and to the right of carene is found a mestome bundle of second type. One primary mestome bundle occurs in carene.

In the carene leptome and hadrome are well developed. The pitted vessels are large. Stereome is well developed on inferior

and superior surfaces of the bundle. In the carene, leptome and hadrome are separated from each other by thick-walled cells. The cells in leptome are somewhat more thick-walled than in hadrome.

In some of the mestome bundles of third type the hadrome is not so well developed; the intercellular space is not evident. This is not the case with mestome bundles of first type, in which this space is very conspicuous. The leptome is in direct contact with stereome, but hadrome is separated by thin-walled parenchyma cells. The bundles of second type are small; leptome and hadrome are but slightly developed, most of the bundles containing only thick-walled cells, while occasionally there is a bundle which has an indication of one or two pitted vessels. In the mestome bundle of third type, the leptome is separated from the stereome by thin-walled parenchyma cells.

In *Festuca elatior* var. *pratensis*, as in *Lolium perenne*, a thin-walled parenchyma sheath surrounds all bundles of the second type, but in all cases thick-walled cells form a closed sheath around leptome and hadrome just inside of parenchyma sheath.

Stereome.—This consists usually of six cells at the margins of leaf and occurs on superior surfaces of all bundles of the first and third types, and occasionally on superior surface of the mestome bundles of second type. It is not, however, strongly developed. Greatest development is reached on superior and inferior surfaces of mestome bundles of carene.

Mesophyll.—This is found between all mestome bundles. The mestome bundles are found not so close as in *Lolium perenne*. The cells are smaller. The smaller occur on superior face. The epidermal cells of stereome region are thick-walled.

FESTUCA TENELLA WILLD.

(Pl. ix, Fig. 2; Pl. x, Figs. 5 and 6.)

Epidermis.—The epidermis is as strongly developed as in *Festuca elatior* var. *pratensis* though not as large as in *Lolium*. The smaller cells occur on superior surface. The cuticle is thicker on inferior surface than on superior surface. The epidermal cells covering the stereome are thick-walled and not as large as the other epidermal cells.

This dry soil grass has involute leaves and, as Hackel says: "In grasses that do not have such fan-shaped cell groups (bulliform cells) the blade remains always folded or rolled up, or at least open but a little." Bulliform cells do not occur, or only as slight differentiation of epidermal cells.

Trichomes are conspicuous, but only on the superior surface, one to three to each bundle.

Mestome bundles.—There are twelve mestome bundles in a leaf, of three types. First, primary type, open both on inferior and superior surfaces of leaf, *i. e.*, those which have hadrome and leptome respectively in contact with stereome, either in direct contact or are separated from it by several rows of thin-walled parenchyma cells. Second, the secondary type. These are entirely surrounded by chlorophyll-bearing parenchyma. Third, intermediate type. These open inferiorly. Only one bundle of primary type occurs and this is in the carene. The leptome and hadrome are in direct contact with each other. The leptome is separated from the stereome by thin-walled parenchyma cells. Quite a development of thin-walled parenchyma cells occurs above the mestome bundles of carene. Two bundles of the third type occur near the margin of leaf. The cells separating the leptome from stereome are in this case somewhat thicker-walled than those in carene.

The mestome bundles of second type are of two sizes, the largest ones having leptome and hadrome poorly developed, and the smallest having no thick-walled cells.

The thin-walled parenchyma, with its inner closed sheath does not differ from that described in *Festuca pratensis* and *Lolium perenne*.

Stereome.—This seems to be more strongly developed in this species than in *Festuca elatior*, variety *pratensis* and *Lolium perenne*. It occurs on the margin of leaf, and also on inferior surface of all bundles of first and third types, and on inferior surface of all large bundles of secondary type.

Mesophyll occupies a small area in this species since the mestome bundles are close together.

BROMUS PATULUS M. & K.

(Pl. ix, Fig. 4; Pl. x, Fig. 7.)

This was thought to be *B. racemosus*.

Epidermis.—The large epidermal cells are thicker-walled than in *Festuca* or *Lolium perenne*.—Over the stereome they are smaller and thicker-walled. The cuticle is thicker on superior than on inferior surface. The leaves are very hairy, and trichomes occur both on inferior and on superior surface, but are more numerous on superior surface.

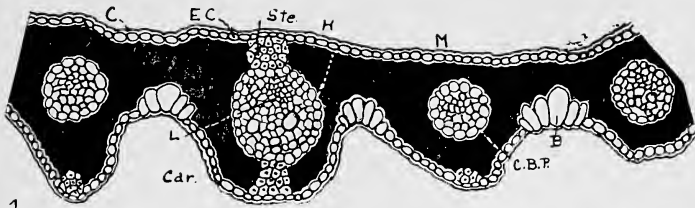


Fig. 1.

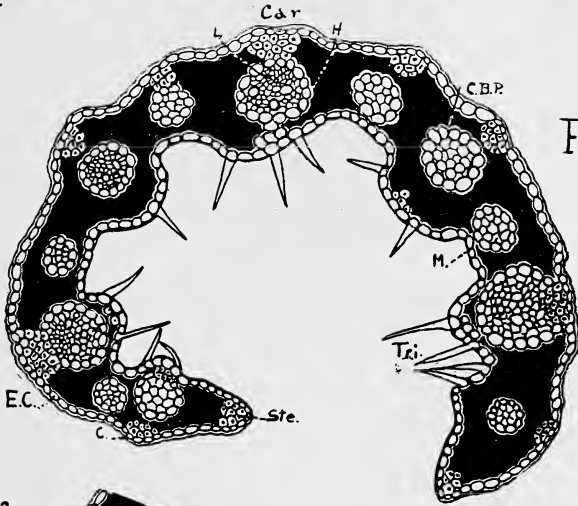


Fig. 2.

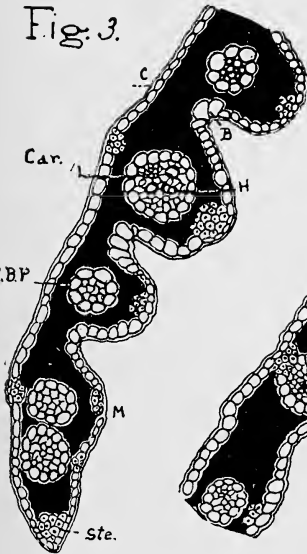


Fig. 3.

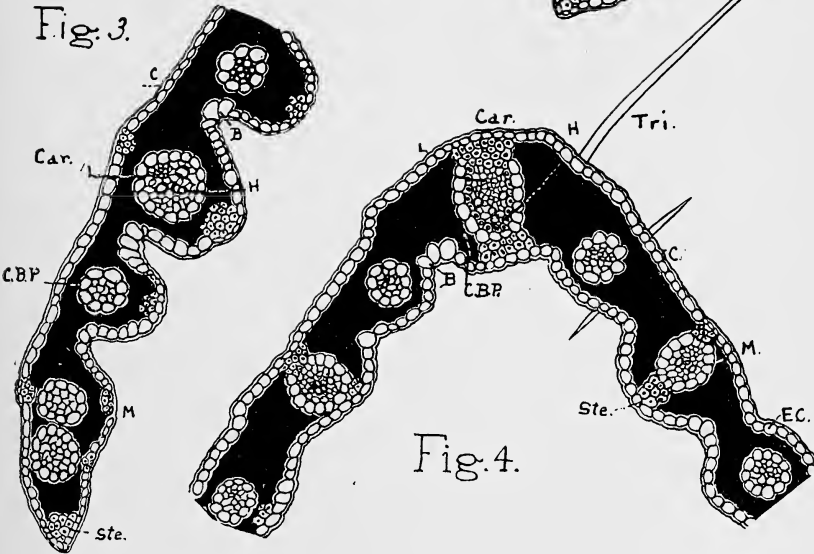


Fig. 4.

Fig. 5.

Car.

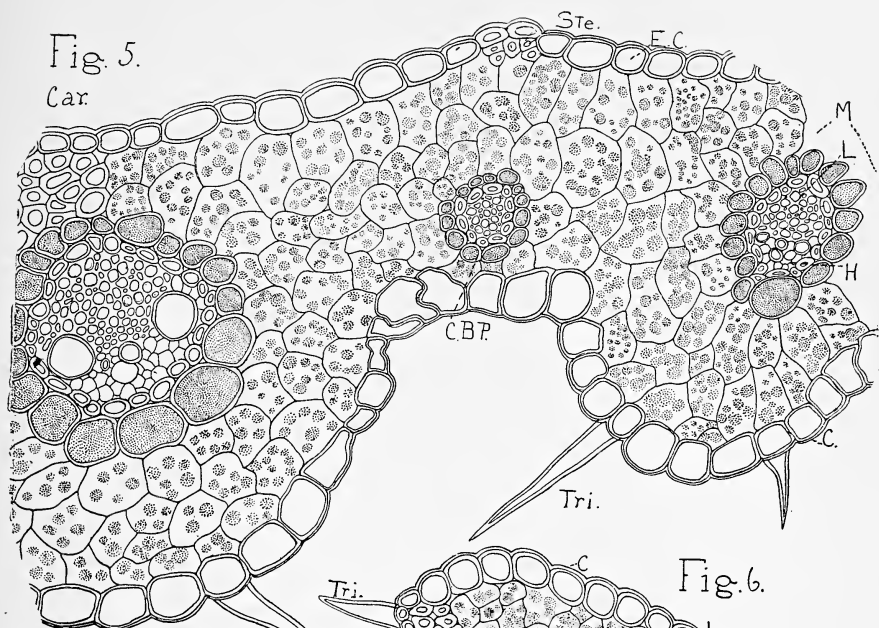


Fig. 6.

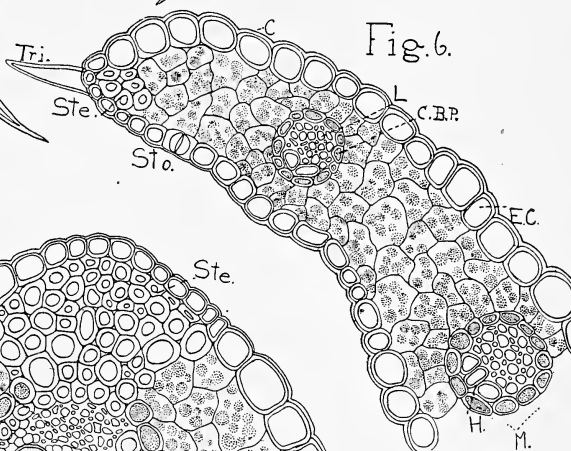
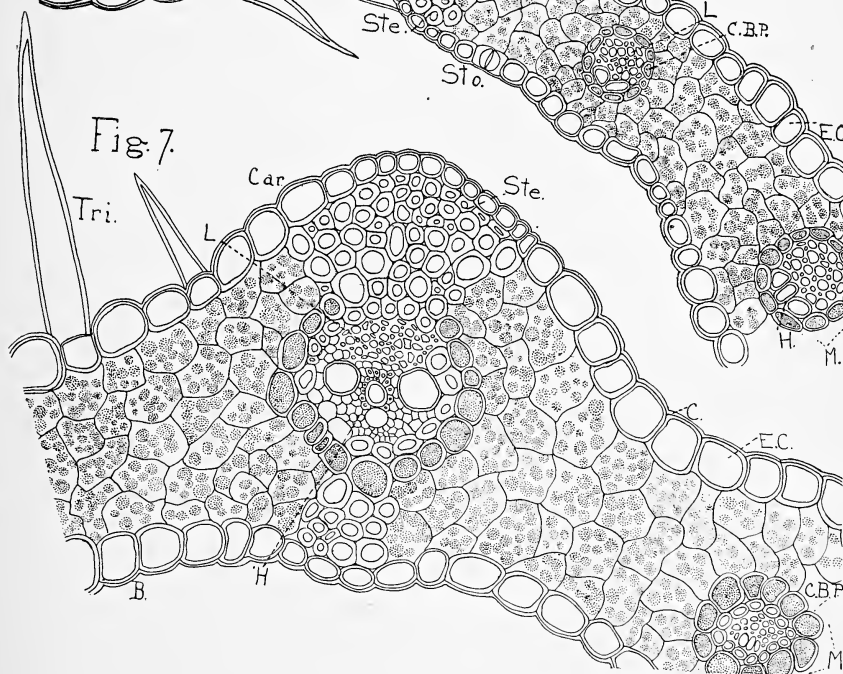


Fig. 7.



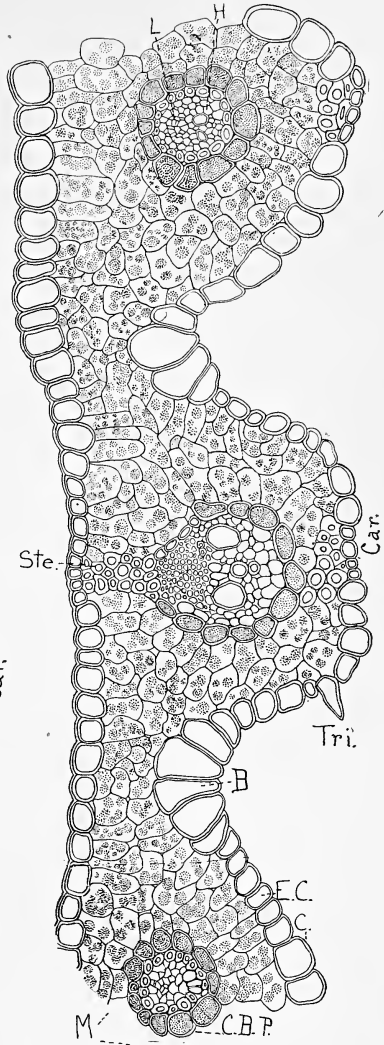
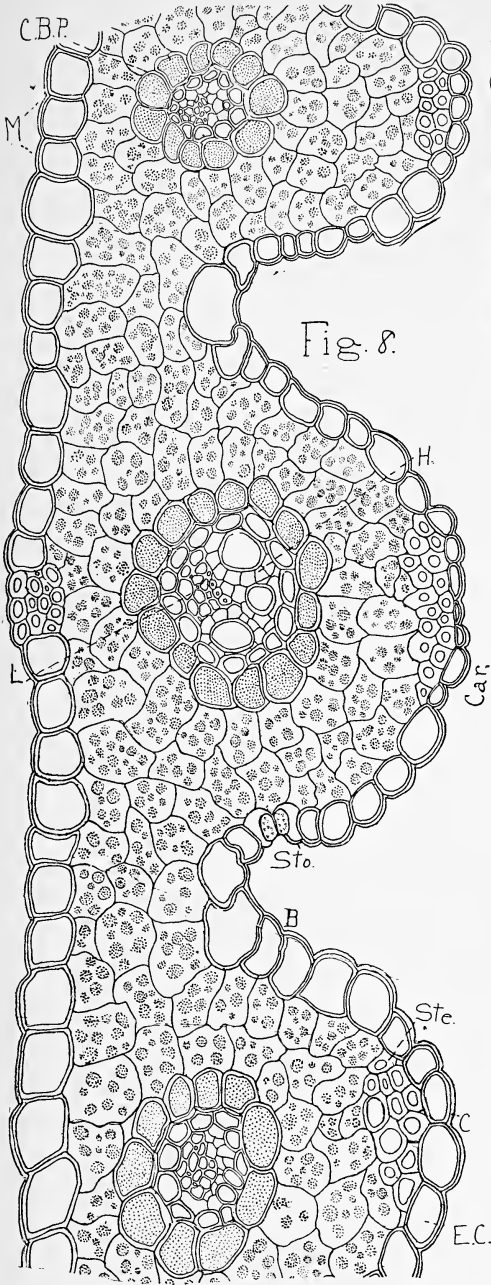


Fig. 9.



Bulliform cells.—The bulliform cells are not greatly differentiated. In a great many cases the cells are hardly to be distinguished from epidermal cells proper. They occur between each mestome bundle and number three.

In the middle of the leaf there are from thirty to thirty-three mestome bundles of three types: primary, secondary and intermediate.

The mestome bundles of secondary type are most numerous, sixteen in each leaf. These bundles are rather small, and occur near the margin of the leaf. Those of the secondary type consist mainly of thick-walled cells with poorly developed pitted vessels. One mestome bundle of second type occurs on each side of mestome bundle of carene.

Three sizes of mestome bundle of first type occur. One is found in the carene. This is the largest; other sizes follow in numerical order, beginning from margin. The smallest is shown in plate IX.

In the two larger, the leptome and hadrome is well developed, and in the smallest bundle the spiral duct in some instances is wanting.

Stereome.—This is quite conspicuous in the carene. Hadrome separated from stereome by colorless parenchyma cells. In carene the stereome is more strongly developed on inferior than on superior surface of mestome bundles. The mestome bundle of second size has the stereome not so well developed on its superior and inferior surfaces as is found in carene. The mestome bundle of third type is of the same size as the smallest of the first type, only they are more numerous.

Stereome is found on the margin of leaf, and numbers from four to six cells; it also occurs on superior and inferior surfaces of all bundles, except those of the second type. It does not occur on either superior or inferior surface of the bundles of second type.

Mesophyll.—This occurs between all mestome bundles. The cells are quite uniform in size.

EXPLANATION OF PLATES.

All drawings were made with the camera, and are drawn to the same scale. The abbreviations used are: C., cuticle; E., epidermis; E. C., epidermal cells; Sto., stoma; Tr., trichomes; B., bulliform cells; Ste., stereome; Mes., mesophyll; C. B. P., chlorophyll-bearing parenchyma; Car., carene; M., mestome bundles; H., hadrome; L., leptome.

PLATE ix, Fig. 1, *Festuca elatior*, var. *pratensis*. Fig. 2, *Festuca tenella*; Fig. 3, *Lolium perenne*; Fig. 4, *Bromus patulus*.

PLATE x, Figs. 5 and 6, *Festuca tenella*; Fig. 7, *Bromus patulus*.

PLATE xi, Fig. 8, *Lolium perenne*; Fig. 9, *Festuca elatior*, var. *pratensis*.

AN ANATOMICAL STUDY OF THE LEAVES OF SOME SPECIES OF THE GENUS ANDROPOGON.

BY C. B. WEAVER.

The purpose of the following paper and accompanying figures is to make an additional contribution to the work already done toward our knowledge of the leaf anatomy of grasses.

Reference to valuable literature along this line of scientific research may be found in the papers by Misses Pammel and Sirrine, on the genera *Sporobolus* and *Panicum*, published in vol. III, of the proceedings of Iowa Academy of Sciences for 1895.

ANDROPOGON PROVINCIALIS.

(Pl. xii, Figs. 2, 3 and 4; Pl. xiv, Fig. 12.)

In this species the epidermal cells (E. C.) are large, nearly round and variable in size. The cuticle (C.) is well developed. The stomata (Sto.) occur in small depressions.

The bulliform cells (B. C.) vary in number from two to six. They seem to merge gradually into the epidermal cells and vary considerably in size. These cells occur between the secondary veins and below the mestome bundles.

In this species four types of bundles occur, viz.: (1) carene, (2) entirely closed, (3) open, (4) larger secondary bundles with stereome (Ste.) both above and below.

The carene (Car.) consists of three large bundles open above and below. The central bundle is but little larger than the secondary bundles. In the hadrome (H) occur the conspicuous pitted and spiral ducts. The chlorophyll-bearing parenchyma cells surrounding the larger bundles are not as conspicuous as those of the smaller mestome bundles. The stereome (Ste.) above the carene is well developed and is wider than the middle larger bundle, while opposite on the lower side of the leaf occur but few stereome cells, and these latter are in direct contact with the epidermal cells. The cells composing the leptome portion (L) of the middle carene bundle are uniform in size.

The uncolored parenchyma cells which occur below and to the side of the middle carene bundle, are large. These cells are in contact with the three large bundles of the carene (Car.) The smaller mestome bundles (M) on either side of the carene occur close together. The chlorophyll-bearing parenchyma cells (C.B.P.) surrounding them are conspicuous. These bundles are not uniform in number on both sides of the mid-rib, which goes to show that the development of the leaf is unequal. On each side of the carene occur four of the larger secondary bundles.

The edges of the leaf are provided with stereome (Ste.) The stereome about the bundles varies in the number of cells.

The cells of the mesophyll (Mes.) occur as dense masses with numerous intercellular spaces. They vary in shape from elongated to spherical. An occasional small trichome (Tri.) (Fig. 4) may be seen.

ANDROPOGON NUTANS.

(Pl. xii, Figs. 1 and 5; Pl. xv, Figs. 14 and 15.)

In this species, as in *A. provincialis*, the epidermal cells (E.C.) are large, nearly round and vary in size. The cuticle (C) is well developed. The conical projections (C. P.) are conspicuous, and more so on the lower than on the upper surface.

The bulliform cells (B. C.) vary in number from two to five. They are more uniform in number than *A. provincialis*, and do not vary so much in size. They occur between the secondary veins and below the smaller closed mestome bundles (M). In this species, as in *A. provincialis*, occur four types of bundles, (1) carene, (2) entirely closed by surrounding chlorophyll-bearing cells, (3) open, (4) large bundles with leptome (L.), and hadrome (H.), more strongly developed. There occasionally occurs a short and sharply pointed trichome emerging from the mestome bundle of the secondary vein. The secondary bundles are open above and below. Stereome (Ste) occurs on both sides of these bundles.

The carene differs from that of *A. provincialis* in the number of pitted and spiral ducts. Its parts are all well developed. The stereome below the carene is not so abundant as in *A. provincialis*, but the reverse is true of the stereome above the carene. The uncolored parenchyma cells between the bundles and upper stereome are more numerous than in *A. provincialis*.

The mestome bundles are not so close together in this species as in *A. provincialis*. The larger bundles vary in number

on either side of the carene, while the number as a whole is uniform, forty-one and forty-nine. The edges of the leaves are completely filled with stereome (Ste.). The stereome occurs only on the lower side of the smaller closed bundles, and in sections of this species is not so abundant as in *A. provincialis*. The mesophyll (Mes.) is more abundant in *A. nutans* than in *A. provincialis*. In shape and size the cells are about the same. In this portion we find small intercellular spaces. The uncolored parenchyma cells about the carene occur in about the same proportion as in *A. provincialis*.

ANDROPOGON SCOPARIUS.

(Pl. xiii, Figs. 6 and 8; Pl. xv, Fig. 13.)

In this species the epidermal cells (E. C.) do not differ in detail essentially from *A. provincialis* and *A. nutans*. They are quite variable in size. Cuticle (C.) is well developed. Trichomes (Tri.) are scattered but conspicuous.

The bulliform cells (B. C.) are sufficiently characteristic to distinguish it from all other species studied. They occur as an almost continual row the entire breadth of the leaf with the exception of above secondary bundles, this space is occupied by stereome.

Stereome occurs in groups of from three to eight cells, more uniform in size than in the other species studied. The principal distinguishing feature between this and other members of the genus studied lies in the continuous row of bulliform cells which occurs across the upper portion of the carene (Car.) this, in other species, is occupied by stereome.

The four types of bundles occur in this species as in others studied. The carene is bulged below. Stereome (Ste.) is abundant. The epidermal cells on the lower surface of the leaf below the carene are somewhat irregular with reference to the cell wall, the latter is also stratified.

The uncolored parenchyma occupies the space between the bulliform cells and the bundles of the carene, forming more or less of a continuous row up to and slightly beyond the first secondary bundle, except for such interruptions due to the development of stereome of bundles of third type. Beyond this it is confined to from two to six cells above the mesophyll. Stereome does not occur above carene as in other species studied. Pitted and spiral ducts are large and well developed. Leptome (L.) and hadrome (H.) are well developed in this species.

The mestome portion is compact. The larger secondary mestome bundles occur in sets of three on either side of the carene. The bundles number twenty-four and twenty-eight on either side of carene. The mestome portion extends nearly to the edge of the leaf, where stereome occurs. The edges of the leaf are rounded.

The stereome portion is quite generally distributed and varies not essentially from this portion in other species. The secondary mestome (M.) bundles are not characteristic.

ANDROPOGON SORGHUM.

(Pl. xiii, Fig. 7; Pl. xiv, Fig. 10.)

Cuticle (C.) and epidermal cells (E. C.) are not characteristic. Bulliform cells (B. C.) vary in number from two to eight. Their size is somewhat variable. These cells merge so gradually into the smaller ones which are usually found above the mestome bundles that it is difficult to distinguish them from the epidermal cells on this side of the leaf. The four types of bundles common in other species studied occur also in this species. The carene is distinguished from that of other species studied in that the chlorophyll-bearing parenchyma cells (C. B. P.) are small, not so regular, and do not contain as much chlorophyll as in other species studied. The intercellular space adjoining the ringed duct is large. The stereome (Ste.) above and below carene bundles is conspicuous. Epidermal cells directly below carene are rectangular in shape. The mestome (M.) bundles are not characteristic in this species. The rectangular chlorophyll-bearing parenchyma cells surround the bundles. The mestome bundles are numerous and occupy the same relative position as in other species studied. Edges of leaf have a well-developed stereome. The number of cells varies. The mesophyll (Mes.) is not so dense as in other species. The shape and size of the cells varies considerably. The uncolored parenchyma cells occur above and to sides of upper half of carene. These cells are unusually large, and occupy a large portion of the mid-rib. They gradually become smaller toward the edges of the leaf. Stereome above parenchyma occurs in from two to three rows. The contents of bundles are not essentially different from others already studied. The breadth of the leaf as well as the large mid-rib is sufficient to characterize it.

ANDROPOGON SORGHUM, VAR. HALEPENSE. HACKEL.

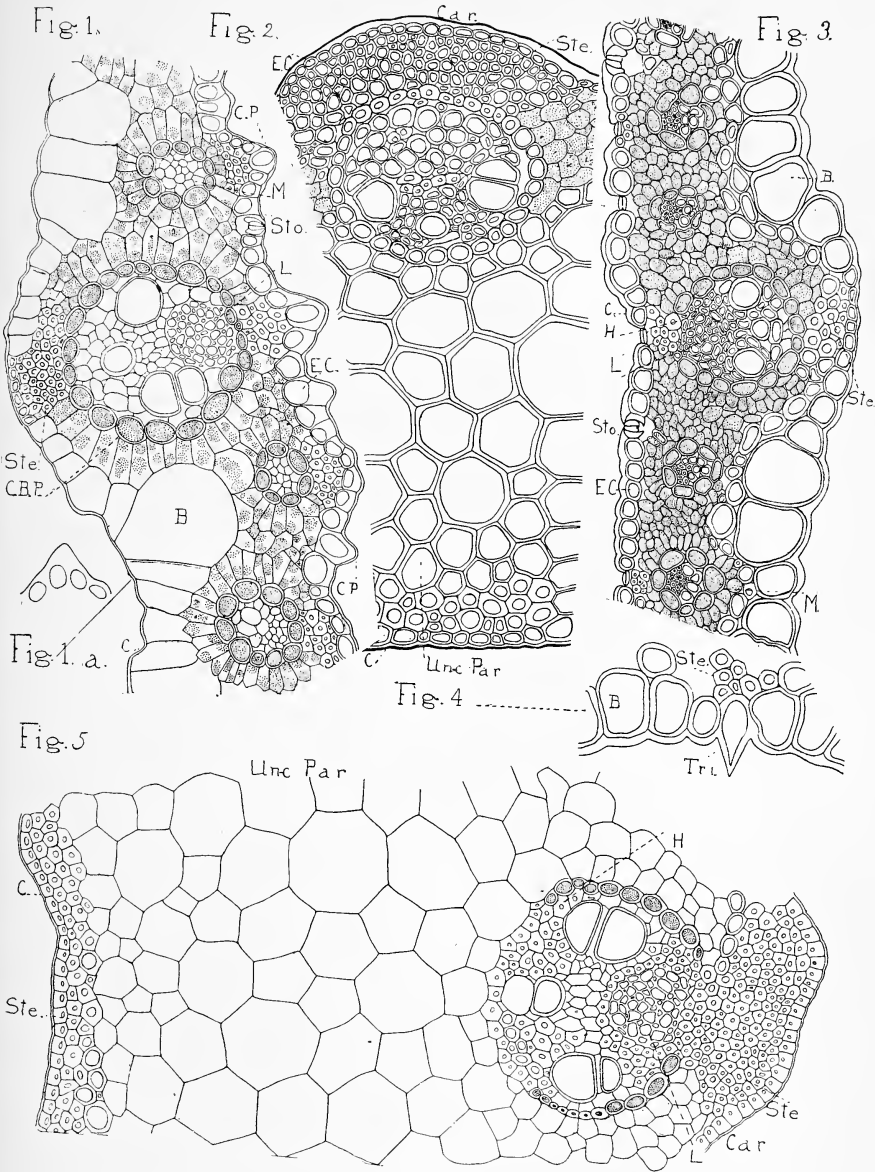
(Pl. xiii, Fig. 9; Pl. xiv, Fig. 11.)

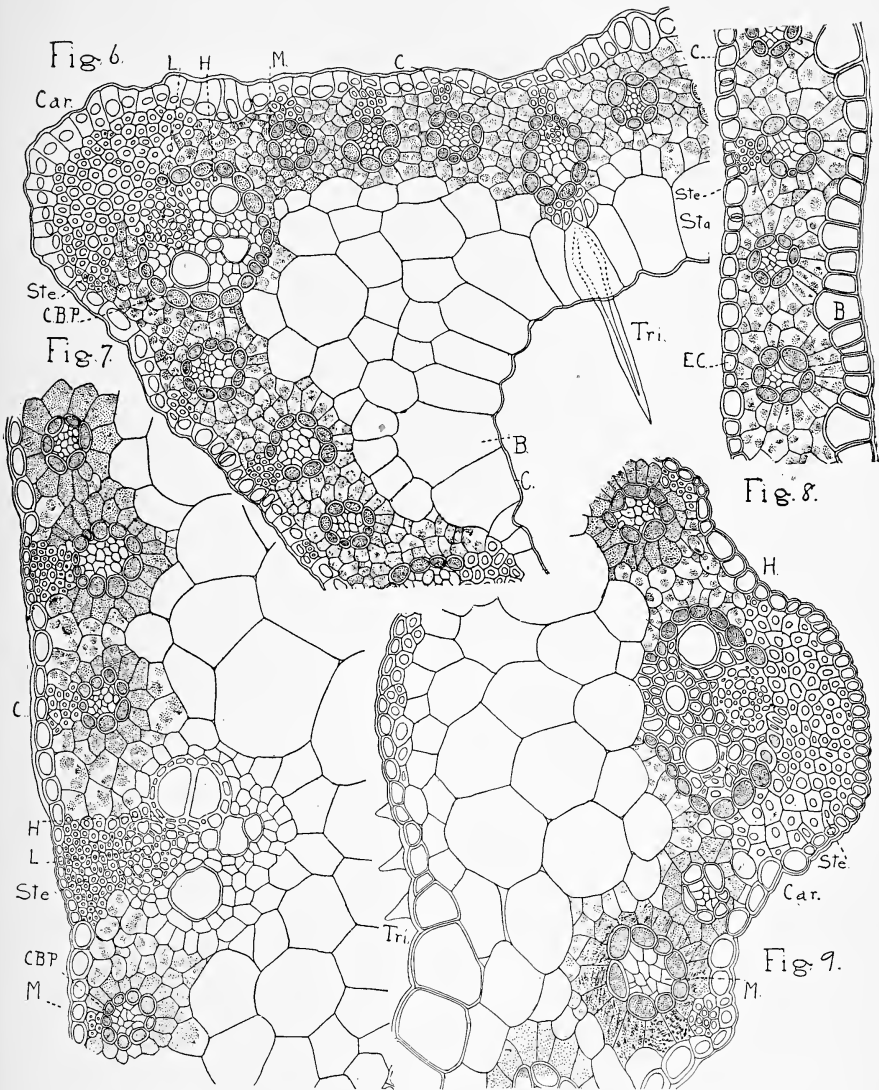
The epidermal cells (E. C.) in this species have a thick cell wall and vary somewhat in size, not as much, however, as in some of the other species. Many of the cells, especially the larger ones, are somewhat elongated. The cuticle is well developed. The bulliform cells (B. C.) vary in number from two to four. These gradually blend into the epidermal cells.

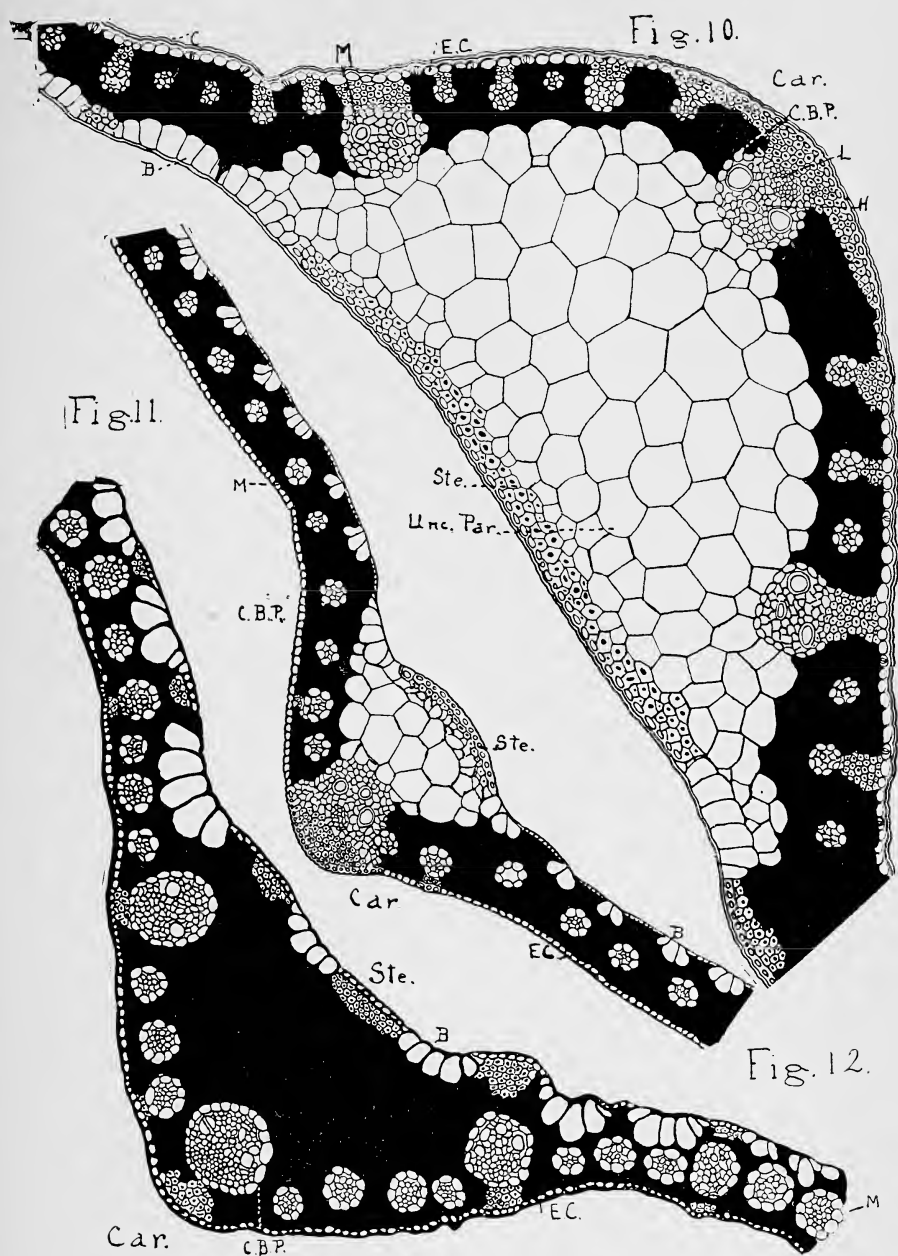
The carene (Car.) consists of five bundles, the large bundles of the mid-rib and two smaller closed mestome bundles on each side; the bundle next to the mid-rib is very small and without stereome. Below the second bundles on each side is found a small group of cells. The large central bundle of the carene does not differ from those of other species. In this variety the leptome (L.) consists of large cells, nearly uniform in size. The pitted ducts occur singly; annular duct is rather large. The interior of the bundle contains very little stereome. Chlorophyll-bearing parenchyma cells surround the bundles and are average in size. Stereome (Ste.) occurs on upper side of leaf, and large bundles are in direct contact with the epidermal cells and consist of two quite regular and distinct layers of cells. The uncolored parenchyma cells are large. The lower surface of mid-rib in this species is decidedly convex. This is also true of *A. sorghum*, but not so marked. The surfaces of the leaf are smooth with the exception of an occasional sharp trichome or conical projection which occurs on the upper surface of the leaf and only in vicinity of the mid-rib. The usual four types of bundles occur. The mestome bundles are not characteristic. The cells of the mesophyll (Mes.) directly surrounding the bundles are elongated. The bundles on either side of the carene occur quite close together. The stereome is confined principally in the vicinity of the carene and larger secondary bundles. The mesophyll portion does not differ materially from that of other species studied. Below stomata (Sto.) occur large intercellular spaces. The edges of the leaf contain conspicuous cells of stereome.

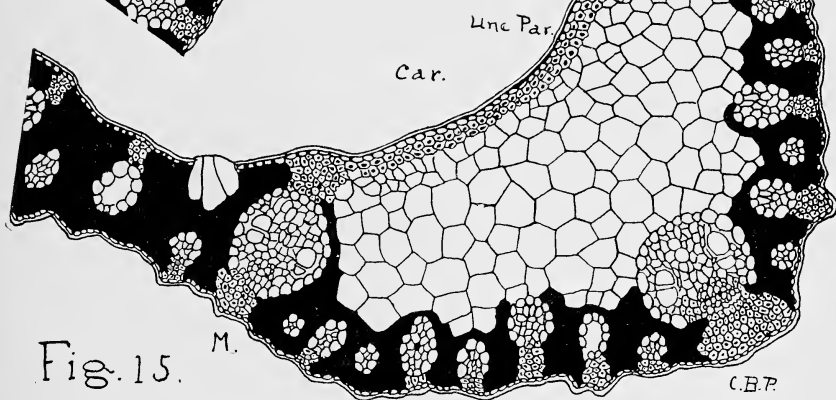
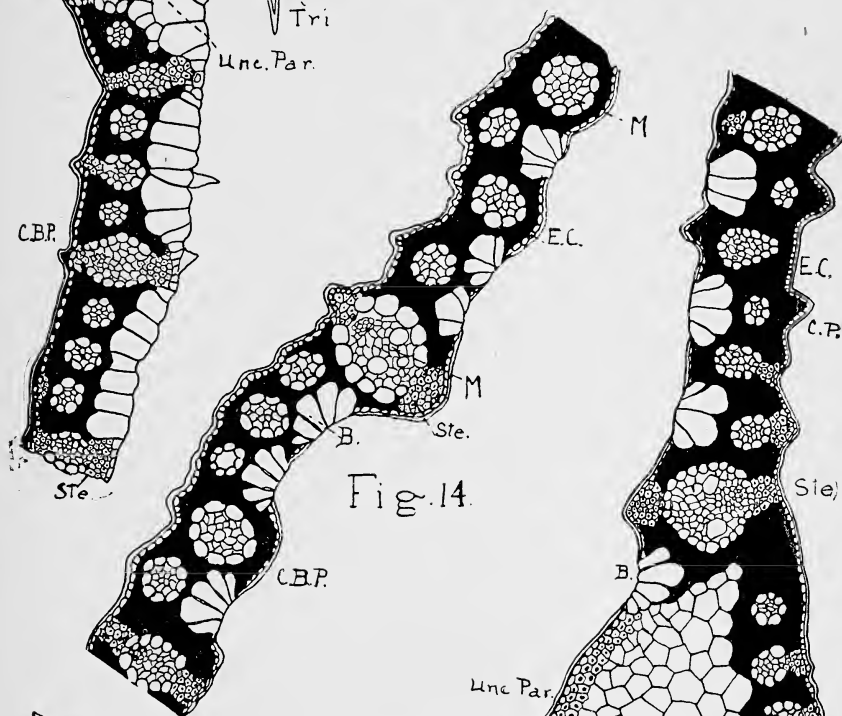
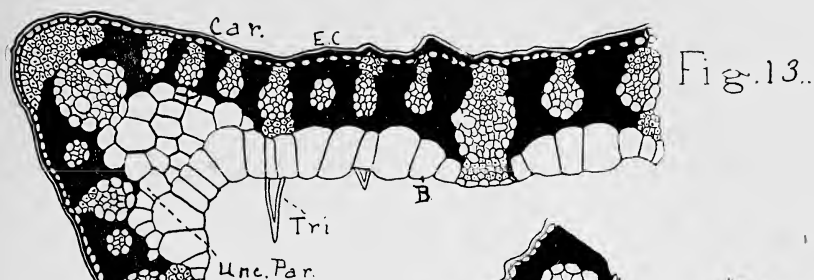
COMPARISON.

A comparison of the species of the genus *Andropogon* which have been studied at this time shows general similarity in anatomical arrangement of parts, and yet, in each species occur characters sufficient to distinguish it. The bundles have the same general arrangement and structure, except some minor









characters. The opened and closed bundles are variable in number and difficult to distinguish, as many of the smaller mesotome bundles are very small and close together.

These species can be distinguished by the following key: Bulliform cells in groups of two to four, occasional short trichomes. *A. provincialis*.

Bulliform cells narrow and long, two to five in number, in some cases decidedly unequal, short trichomes very numerous. *A. nutans*.

Bulliform cells three to eight, uniform in size, forming an almost continuous row, also above the carene, trichomes conspicuous. *A. scoparius*.

Bulliform cells vary in number from two to eight, in definite groups, gradually merge into the epidermal cells; smooth. *A. sorghum*.

Bulliform cells vary in number from two to four, granduallly blending into the epidermal cells. Trichomes few and small near carene. *A. sorghum*, var. *Halepense*.

CONCLUSION.

In conclusion it may be said that each species of the genus presented here has individual peculiarities which are strong enough to distinguish it from other species of the genus. I believe also that a study of the anatomical characters offered in grasses will show characters enough to distinguish genera and, in many cases, species and even varieties, as for example, in *A. sorghum* and *A. sorghum*, var. *Halepense*. By these studies one may receive material aid in the classification and the determination of many grasses.

Thanks are due to Mr. Barnes of Blue Grass, who kindly sent the leaves of *A. sorghum*, var. *Halepense*.

EXPLANATION OF PLATES.

The same letter is used for the same character in all of the figures. C., cuticle; E., epidermis; E. C., epidermal cells; Sto., stomata; Tri., trichome; C. P., conical projections; B. C., bulliform cells; Unc. Par., uncolored parenchyma; C. B. P., chlorophyll-bearing parenchyma; Mes., mesophyll; Ste., stereome; M., mestome; Car., carene; H., hadrome; L., leptome.

The figures are all drawn with camera to the same scale. Low power with one half inch Beck objective; detailed drawings with one-sixth inch Beck objective.

Figs. 1-9 are reduced three times; Figs. 10-15 not reduced.

PLATE xii, Figs 1 and 5, *Andropogon nutans*; Figs. 2, 3 and 4, *Andropogon provincialis*.

PLATE xiii, Figs 6 and 8, *Andropogon scoparius*; Fig. 7, *Andropogon sorghum*. Fig. 9, *A. sorghum*, var. *Halepense*.

PLATE xiv, Fig. 10, *A. sorghum*; Fig. 11, *A. sorghum*, var. *Halepense*; Fig. 12, *A. provincialis*.

PLATE xv, Fig. 13, *A. scoparius*; Figs. 14 and 15, *A. nutans*.

AN ANATOMICAL STUDY OF THE LEAVES OF
ERAGROSTIS.

BY CARLETON R. BALL.

This study was undertaken in order to ascertain if the anatomical characters in the leaves of this genus were sufficiently well marked and constant to be of value in identifying the different species. The results of similar studies by others have been encouraging. Prominent among these is the series of excellent papers by Theodore Holm¹, who has studied six genera—*Uniola*, *Distichlis*, *Pleuropogon*, *Leersia*, *Oryza*, and *Amphicarpum*, and considers the anatomical characters of all except *Distichlis* to be a reliable basis for determining the different species. Emma Sirrine and Emma Pammel² have studied *Sporobolus* and *Panicum* and conclude that the species in these genera, so far as studied, may be differentiated by means of their anatomical structure.

In this paper the author has considered six species of *Eragrostis*, viz.: *E. reptans* Nees, *E. pectinacea* Gray, *E. purshii* Schrad., *E. frankii* Meyer, *E. mexicana* and *E. major* Host.

In these species three structural types of mestome bundles occur: primary or open bundles (Pl. XVII, Fig. 8.) in which the chlorophyll-bearing parenchyma sheath is found only at the sides of the bundles and is wanting above and below them; secondary or closed bundles (Pl. XVII, Fig. 13, vein 3,) in which this sheath completely surrounds the bundle, separating the leptome from the stereome below and the hadrome and thick-walled parenchyma from the stereome, mesophyll, or parenchyma above; intermediate bundles in which this sheath is interrupted either above or below the bundle.

¹ A Study of Some Anatomical Characters of No. Am. Gramineae, Bot. Gaz., Vol. XVI, pp. 166, 217, 275; Vol. XVII, p. 358; Vol. XX, p. 382; Vol. XXI, p. 357; Vol. XXII, p. 403.

² Some Anatomical Studies of the Leaves of *Sporobolus* and *Panicum*, Proc. Ia. Acad. Sci., 1895, Vol. III, p. 148. (An extended bibliography of this subject may be found in this paper.)

These different types do not always occupy the same relative position in the leaves of the different species.

In the species studied, these bundles are found to occur in three distinct sizes with constant positions. This would have afforded a basis of nomenclature for the bundles but for the fact that it does not hold good for other genera, and hence is not used. However, for convenience in locating the structural types described above, their position in the leaf is indicated by the parenthesis "(carene)" which is the largest vein in the leaf and always central; "(vein 2)" the next smaller veins, occurring at nearly regular intervals between the carene and the edge of the leaf (Pl. xvi, Fig. 2); and "(vein 3)" the smallest veins, which occur in groups of three to six between the medium veins (vein 2) and also between them and the carene.

ERAGROSTIS REPTANS NEES.

(Pl. xvi, Fig. 1; Pl. xviii, Figs. 17 and 18.)

Epidermis.—This, the smallest of the species studied, presents the most striking variations from the general type, especially in the epidermal characters. The walls of the epidermal cells on the superior surface are quite thin, while those of the inferior surface are thicker. The inferior epidermal cells are nearly equal in size, as are those of the superior surface, but these latter are much larger in proportion than those of any other species. Stomata occur frequently on both surfaces, on either side of the mestome bundles. Trichomes are long, slender, pointed, one-celled hairs, occurring in single rows on all bundles. The two adjacent epidermal cells, in some cases, extend obliquely upwards beside the base of the trichome.

Bulliform cells.—The bulliform cells are two or three in number, and in some cases not easily distinguishable from the epidermal cells.

Mestome bundles.—The mestome bundles are thirteen in number, and are all of the intermediate type. The chlorophyll-bearing parenchyma sheath is composed of four or five large cells and is open below. Leptome, hadrome and thick-walled parenchyma are well developed in all the bundles. In the bundles of the carene and vein 2 the mestome sheath is interrupted above by the stereome, but in the other bundles (vein 3) it is continuous.

The carene bundle differs from the other bundles only in being slightly larger, and in having the leptome entirely surrounded by thick-walled parenchyma.

The mesophyll is normal, and the stereome rather small in quantity.

ERAGROSTIS PECTINACEA GRAY.

(Pl. xvi, Fig. 5; Pl. xvii, Figs. 9 and 11.)

Epidermis.—The cuticle of both surfaces is well developed. Walls of superior epidermal cells thicker than those of inferior cells. Epidermal cells of both surfaces more nearly equal in size than in any other species except *E. reptans*. Stomata occur on both surfaces as in the preceding species. Trichomes short, thick, mostly blunt, of irregular size and occurrence above the bundles.

Bulliform cells.—From three to five in number, the central one much the largest and flask-shaped, the long neck lying between the adjacent cells.

Mestome bundles.—These are about fifty-seven in number. Forty-six are of the secondary type (vein 3) and eleven of the intermediate type (carene and vein 2). The chlorophyll-bearing parenchyma sheath of the secondary bundles is the most striking character in this species. It is distinctly triangular in outline, with the apex directed toward the superior surface. The lateral cells are elongated transversely to the section, and the inferior or basal cells are small and nearly round. Hadrome, leptome and thick-walled parenchyma are well developed.

The intermediate bundles (carene and vein 2) are open below, with the leptome surrounded by stereome. The chlorophyll-bearing parenchyma sheath in these bundles does not have the triangular outline. Hadrome and thick-walled parenchyma are strongly developed.

The mestome sheath in both types is interrupted above the bundles by stereome. The carene can be distinguished from the other intermediate bundles only by its position.

Stereome.—Stereome occurs below all bundles as a compact group of large cells, twenty to thirty in number, and above the bundles in small groups of three to six large cells. In some of these cells the cavity is in the form of an elongated oval. Stereome also surrounds the leptome in the intermediate bundles and extends upwards partially around the hadrome.

The mesophyll presents no distinctive characters and colorless parenchyma is absent.

ERAGROSTIS PURSHII SCHRAD.

(Pl. xvi, Fig. 2; Pl. xviii, Figs. 15 and 16.)

Epidermis.—The epidermal cells of both surfaces have thinner walls than in *E. pectinacea*. The cells vary considerably in size, those directly above or below a bundle being much smaller than those adjacent to the mesophyll. Stomata occur frequently on both surfaces, and the air spaces are large. Trichomes are longer than in any species except *E. reptans*, and are thick, usually pointed. Above the intermediate bundles they occur in two or more rows.

Bulliform cells.—These, four to seven in number, are large and quite evenly graded in size from the large central cell to the smaller outer cells.

Mestome bundles number twenty one, of which sixteen are secondary and five are intermediate in type. In the secondary bundles (vein 3) the chlorophyll-bearing parenchyma sheath is nearly round in outline and composed of seven or eight subcircular cells. Hadrome, leptome and thick-walled parenchyma are not so well developed as in the preceding species.

The intermediate bundles (carene and vein 2), five in number, are open below. Hadrome, leptome and thick-walled parenchyma are well developed, the latter especially so. The chlorophyll-bearing parenchyma sheath is composed of from ten to fifteen cells.

The mestome sheath is continuous above and sometimes below the secondary bundles, but is interrupted by stereome above the intermediate type. The carene is but little enlarged and not easily distinguished from vein 2 except by its position.

Stereome is present in quantity both above and below the intermediate bundles and occurs in small groups of three or four cells in the secondary bundles. The mesophyll passes beneath some of the secondary bundles as a single layer of cells.

ERAGROSTIS FRANKII MEYER.

(Pl. xvi, Fig. 6; Pl. xvii, Figs. 10, 12 and 12a.)

Epidermis.—Walls of the epidermal cells slightly thinner than in *E. purshii*. The epidermal cells of the inferior surface vary greatly in size, those beneath the bundles being much smaller than those beneath the mesophyll. Stomata are less frequent in this than in the other species. Trichomes are short, rounded or pointed, and occur on all bundles.

Bulliform cells.—These are five or six in number, are more evenly graded in size than in any other species.

Mestome bundles.—The mestome bundles are thirty-five in number, representing all three types. Of the primary type (vein 2) there are four bundles, in which the leptome, hadrome and thick-walled parenchyma are well developed. These veins (vein 2) are enlarged on the superior face but not on the inferior face. The chlorophyll-bearing parenchyma sheath consists of four or five cells on each side of the bundle, being interrupted below by stereome and above by a few cells of thick-walled parenchyma.

There are thirty secondary bundles (vein 3) containing normal leptome, hadrome and thick-walled parenchyma. The chlorophyll-bearing parenchyma sheath is subpyramidal in outline and composed of five to seven large, subcircular cells with two smaller cells below. The intermediate type is found only in the carene and is open below. Leptome, hadrome and thick-walled parenchyma are strongly developed, the latter passing down to the side of the leptome, which is surrounded by stereome.

The mestome sheath is continuous above the secondary bundles, but above the primary bundles it is interrupted by stereome and above the intermediate bundles by colorless parenchyma.

Carene.—The carene, already discussed as the intermediate bundle, is much enlarged on the inferior side and somewhat so on the superior side. It contains much mesophyll and stereome and some colorless parenchyma.

Stereome occurs in small quantities both above and below the primary and secondary bundles and in much larger quantity in the carene. Directly beneath the center of the carene the stereome is normal in appearance (at x pl. xvii, Fig. 12a) but on either flank it is curiously modified (z pl. xvii, Fig. 12a.) The cell wall is much thinner and does not have the strong greenish yellow color of the normal cell wall. The inner portion of the cell is dark colored and in the very center is a small black dot or cavity. This modified stereome is also found in the same part of the carene of *E. mexicana* and *E. major*. Stereome also surrounds the leptome in primary and intermediate bundles.

Mesophyll is abundant in the enlarged carene and normal elsewhere in the leaf. Four or five cells of colorless parenchyma are found in the carene between the stereome and the chlorophyll-bearing parenchyma sheath.

ERAGROSTIS MEXICANA.

(Pl. xvi, Fig. 3; Pl. xvii, Figs. 7 and 8.)

Epidermis.—The walls of epidermal cells intermediate in thickness between those of *E. purshii* and *E. pectinacea*. Epidermal cells, small below the bundles and large below the mesophyll. Stomata frequent on both surfaces. Trichomes short, thick, one-celled, occurring on all bundles.

Bulliform cells, five to six in number, the central one large and broad.

Mestome bundles.—There are forty-one mestome bundles, of the primary and secondary types. The primary bundles (carene and vein 2) are nine in number, with well-developed hadrome, thick-walled parenchyma and leptome, the latter surrounded by stereome. In the carene the chlorophyll-bearing parenchyma sheath is interrupted above the bundle by colorless parenchyma, but in the other primary bundles (vein 2) by thick-walled parenchyma.

The thirty-two secondary bundles are surrounded by a chlorophyll-bearing parenchyma sheath composed of eight or nine large cells, the two inferior cells having less chlorophyll than the rest. Leptome, hadrome and thick-walled parenchyma are not strongly developed.

The mestome sheath is continuous above the secondary bundles (vein 3) but is interrupted in the primary bundles (vein 2) by stereome or, in the carene, by colorless parenchyma.

The carene is very large, the bundle being in the inferior part of it and subtended by a large quantity of stereome, while the upper part of it is filled by fifteen or twenty large cells of colorless parenchyma, flanked by mesophyll.

Stereome is present in the usual quantity about the secondary bundles (vein 3) and in greater quantity above and below the primary bundles. Mesophyll is found abundantly in the carene, and as usual between the secondary bundles. Colorless parenchyma occurs only above the carene bundle.

ERAGROSTIS MAJOR HOST.

(Pl. xvi, Fig. 4; Pl. xvii, Figs. 13, 14, 19 and 20.)

Epidermis.—The walls of inferior epidermal cells are thick; those of the superior surface, as in *E. mexicana*. Stomata occur regularly on both surfaces. The trichomes are like those of the preceding species.

On the margins of the leaves, and on the median nerve of the sterile and flowering glumes occur numerous small button-shaped projections—the scent glands. (Pl. xvii, Figs. 19 and 20.)

Prof. Wm. Trelease³ says of these glands: "Morphologically the glands are epidermal structures consisting of a single layer of cells, the outermost of which are but little different from those of the adjacent epidermis, but gradually elongating vertically.

Those at the center of the gland are considerably elongated at right angles to the surface, as is usual in epidermal secreting cells, but occasionally septate. While the peripheral cells have thick-pitted walls, and resemble the other cells of the epidermis in having transparent, watery contents, those at the center are much thinner-walled, and filled with coarsely granular yellow protoplasm. As compared with the unmodified epidermal cells, these elongated glandular cells are also thin-walled at top, where, in common with the other elements of the epidermis, they are invested with a rather heavy cuticle. In some cases this membrane is seen to be free from the crater of the gland in the form of a blister, while in others it had been ruptured, so that only fragments are present."

Bulliform cells.—These are small in proportion, especially above the carene, and vary from four to six in number.

Mestome bundles.—Thirty-one in number, of the secondary and intermediate types. Of the secondary type (vein 3) there are twenty-four, surrounded by a chlorophyll-bearing parenchyma sheath of eight or nine large cells, and containing leptome, hadrome, and thick-walled parenchyma. The intermediate bundles (carene and vein 2) are seven in number, open below, and contain strongly developed hadrome and thick-walled parenchyma, with leptome in greater quantity than usual, and entirely surrounded by stereome.

The mestome sheath is continuous above the secondary bundles, but interrupted by stereome above the intermediate bundles of vein 2 and by colorless parenchyma above the carene bundle.

The carene is much enlarged and contains a few cells of colorless parenchyma and considerable mesophyll. The latter is normal in quantity in the rest of the leaf.

³ The Glands of *Eragrostis major*, Host, Proc. Soc. Prom. Agr. Sci., 1889, p. 70.

There is more stereome above and below the secondary bundles, than in *E. mexicana*, and strong groups are found about the intermediate bundles.

CONCLUSIONS.

The results of this study are embodied in the analytical key which follows. The characters given will clearly separate the different species, though, with the exception of the peculiar glands of *E. major*, the differences between *E. mexicana* and *E. major* are not well marked. For instance, the number of cells of colorless parenchyma is constant in neither species, nor is there an absolute line of demarcation between these cells and the mesophyll. Again, while the carene bundle of *E. mexicana* is classed as an intermediate bundle, it will be noticed that the three large cells which form the superior part of the chlorophyll-bearing parenchyma sheath resemble very closely, in their shape, cell-wall, and the almost entire absence of chlorophyll, the adjacent cells of colorless parenchyma.

In conclusion, the author wishes to acknowledge his obligation to Prof. L. H. Pammel, under whose efficient direction the work has been done, for his invaluable assistance and advice; also to Miss Charlotte M. King, artist for the botanical department, for kind suggestions and assistance. Thanks are also due to Mr. F. R. Clements, of Lincoln, Neb., and Mr. W. D. Barnes, of Blue Grass, Iowa, who kindly furnished specimens for study.

ANALYTICAL KEY.

All mestome bundles provided with a chlorophyll-bearing parenchyma sheath; mestome sheath composed of a single row of cells radially arranged; stereome above and below all bundles.

- A. Superior epidermal cells of nearly equal size and all larger than the largest of the inferior epidermal cells; trichomes one-celled, long, slender, pointed. *E. reptans*.
- B. Superior epidermal cells unequal in size and not larger than the inferior cells; trichomes short and thick.
- I. Chlorophyll-bearing parenchyma sheath in bundles of secondary type (vein 3) distinctly pyramidal in outline, apex directed toward superior surface; lateral cells of sheath elongated transversely to the section. *E. pectinacea*.
- II. Chlorophyll-bearing parenchyma sheath in bundles of secondary type (vein 3) round or oval in outline.
- a. Carene not enlarged (or but little), especially on inferior side, not easily distinguishable from vein 2; trichomes equal in length to

one-fourth or one-third the width of section; no colorless parenchyma. *E. purshii*.

- b. Carene enlarged preceptibly, especially on inferior side, easily distinguishable; trichomes equal in length to one-tenth or one-sixth of the section; colorless parenchyma present.
1. Leaf small; upper surface presents a fluted appearance in section; carene and vein 2 strongly developed, the latter on superior side especially; chlorophyll-bearing parenchyma sheath in secondary bundles (vein 3) subpyramidal in outline; cells of same subcircular and the inferior cells much smaller than the rest. *E. frankii*.
2. Leaf large, fluted but little on superior surface; carene enlarged on inferior side only; vein 2 not enlarged; chlorophyll-bearing parenchyma sheath circular in outline; cells subcircular, equal in size.
- † Colorless parenchyma, fifteen to twenty cells, interrupting the mestome and chlorophyll-bearing parenchyma sheaths above the bundles in the carene. *E. mexicana*.
- †† Colorless parenchyma, three to five cells, interrupting the mestome sheath above the bundle in the carene; small button-shaped scent glands, numerous on the margins of all leaves and on the median nerve of both sterile and flowering glumes. *E. major*.

EXPLANATION OF PLATES.

All the figures were drawn from nature by the author and prepared for the engraver by Miss Charlotte M. King, artist for the botanical department.

The abbreviations used are: C., cuticle; E. C., epidermal cells; Tr., trichome; Sto., stoma; B., bulliform cells; Ste., stereome; Mes., mesophyll; M. S., mestome sheath; C. P., colorless parenchyma; C. B. P., chlorophyll-bearing parenchyma; H., hadrome; L., leptome; Sup., superior; inf., inferior; Car., carene; Vein 2, vein next smaller than carene; Vein 3, smallest veins.

PLATE xvi. All drawings on this plate were made with camera, and drawn to the same scale. Fig. 1, *E. reptans*, carene to margin; Fig. 2, *E. purshii*, carene to second vein 2; Fig. 3, *E. mexicana*, carene to first vein 2; Fig. 4, *E. major*, carene to first vein 2; Fig. 5, *E. pectinacea*, carene to first vein 2; Fig. 6, *E. frankii*, carene to first vein 2. Mesophyll and epidermis colored black.

PLATE xvii. All drawings on this plate, except Fig. 12a, made with a one-sixth inch objective. Fig. 12a, drawn with a one-tenth inch oil immersion objective. All reduced one-half. Fig. 7, *E. mexicana*, carene and vein 3, primary and secondary types, respectively; Fig. 8, *E. mexicana*, vein 2, primary type; Fig. 9, *E. pectinacea*, carene, intermediate type, and vein 3, secondary type; Fig. 10, *E. pectinacea* vein 2, intermediate type; Fig. 11, *E. frankii*, vein 2, primary type; Fig. 12, *E. frankii*, carene, intermediate type, and vein 3, secondary type; Fig. 12a, *E. frankii*, inferior part of carene; X, normal stereome; Z, modified stereome.

PLATE xviii. All drawings on this plate made with a one-sixth inch objective; all reduced one-half. Fig. 13, *E. major*, vein 3, secondary type, vein 2, intermediate type; Fig. 14, *E. major*, carene, intermediate type; Fig. 15, *E. purshii*, vein 2, intermediate type; Fig. 16, *E. purshii*, carene, intermediate type and vein 3, secondary type; Fig. 17, *E. reptans*, veins 2 and 3, intermediate type; Fig. 18, *E. reptans*, carene and vein 3, intermediate type; Fig. 19, *E. major*, scent gland, superficial view; Fig. 20, two scent glands on leaf margin, *E. major*.

Fig. 1.

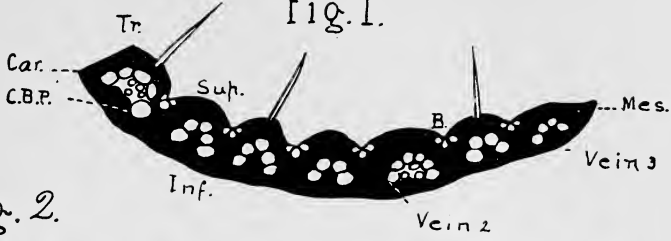


Fig. 2.

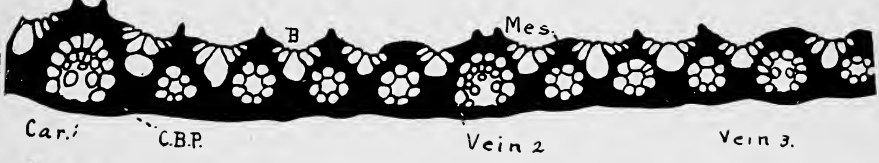


Fig. 3.

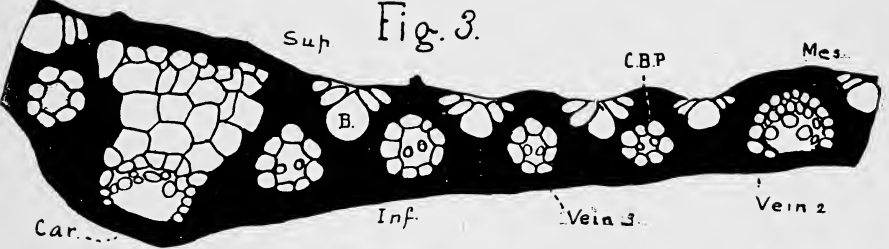


Fig. 4.

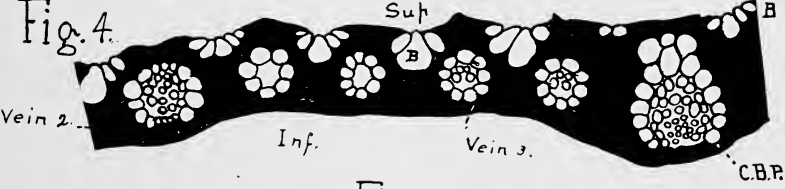


Fig. 5.

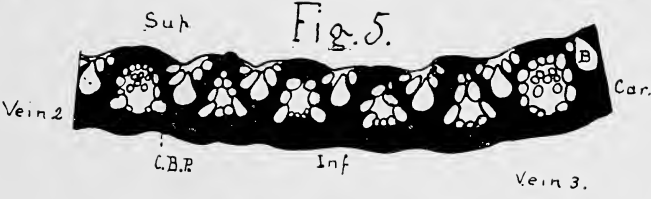
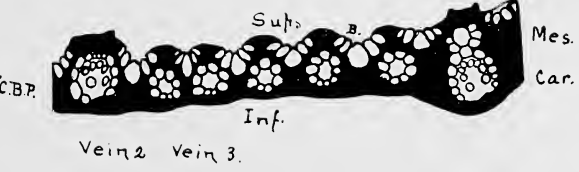
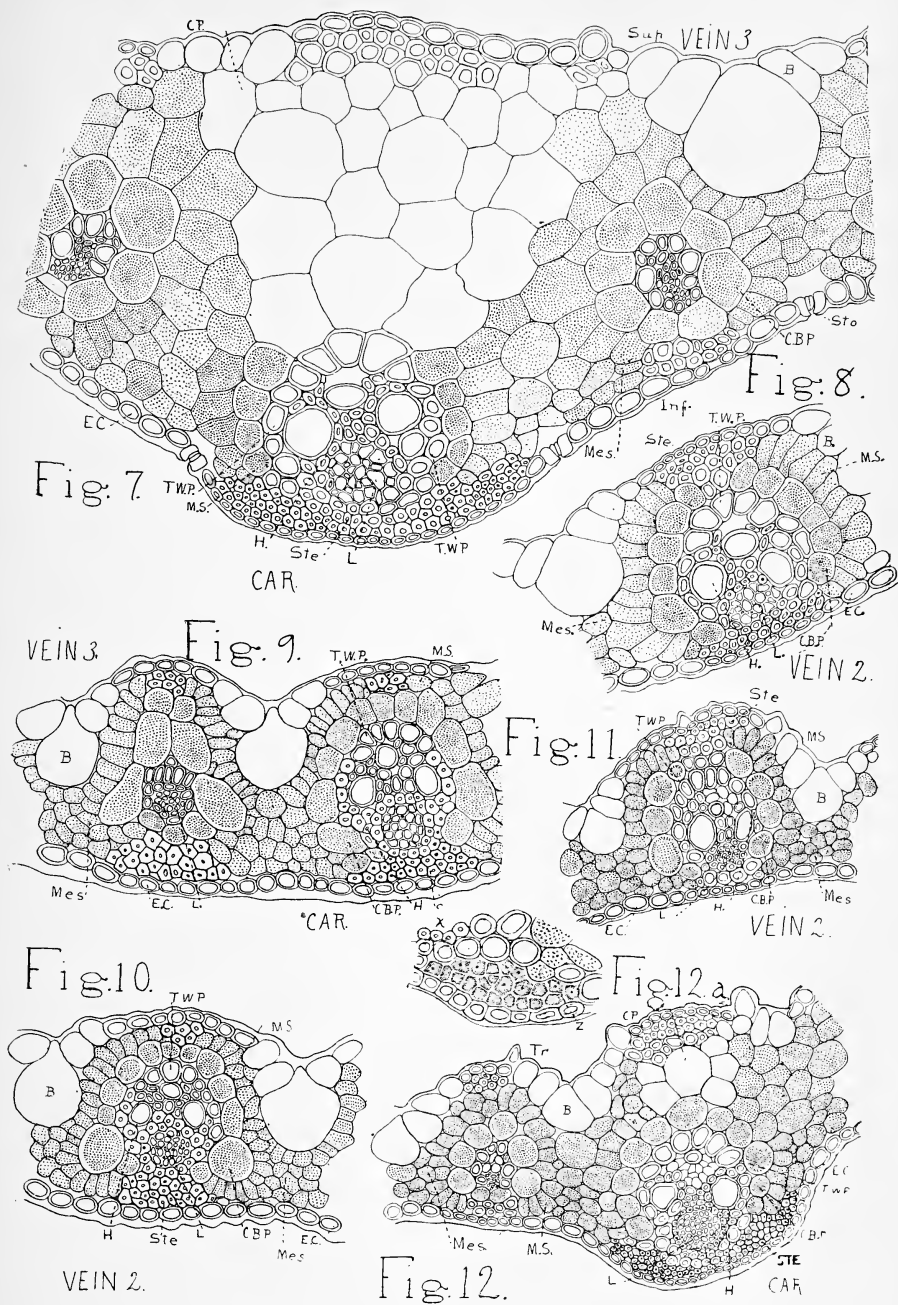
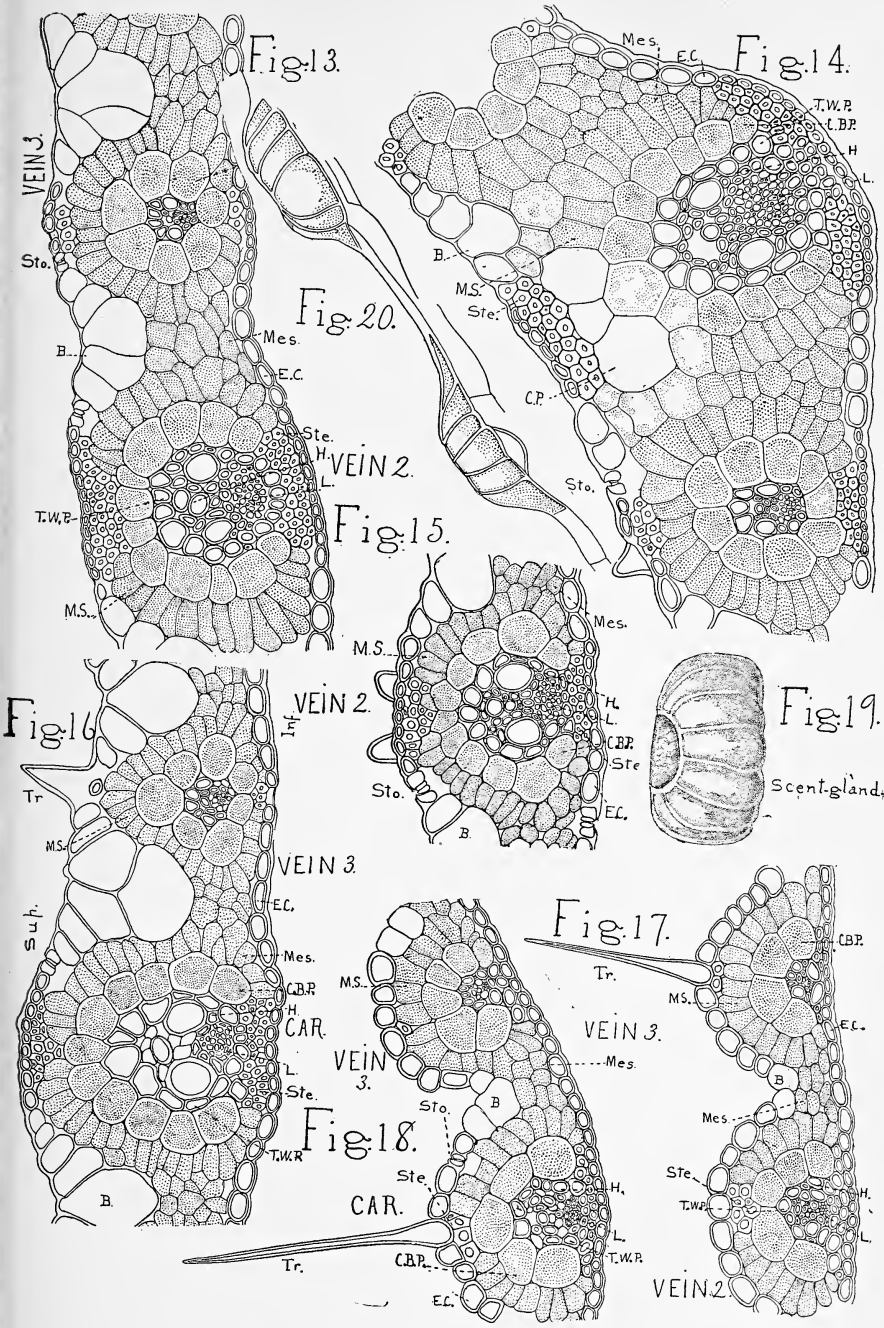


Fig. 6.







THE USES OF FORMALDEHYDE IN ANIMAL MORPHOLOGY.

BY GILBERT L. HOUSER.

By the term *formaldehyde*, I wish to designate a 40 per cent solution of the gas formaldehyde in water. Several articles answering to this description have been placed on the market under trade names such as the "Formalin" of Schering, the "Formol" of Merck, and the "Formalose" of Richards & Co. So far as I have tested these various preparations, they all agree as to composition, and yield perfectly similar results. My attention was first directed to formaldehyde as a morphological reagent in July, 1894, and I have been using it in my work, and have experimented with it in various directions since that time. It certainly possesses several most remarkable properties; so remarkable, in fact, that certain phases of laboratory work in animal morphology are ultimately destined to undergo a revolution through its use.

I. FORMALDEHYDE AS A GENERAL PRESERVATIVE.

It has been urged many times that the zoological specimens placed in the hands of students for class-work are too often mere caricatures of the living animals themselves, and that various erroneous conceptions about nature are thus sure to arise. Granting that we should, as far as possible, use fresh material for study, the fact remains that there are many animals which must be preserved if we are to study them at all. The whole of the group Echinoderma, and, with one exception, all the members of the Coelentera, are cases in point. Such animals have to be preserved at some distant point and transported to us. Now, formaldehyde has its most important and its most far reaching application in this particular field of morphological work. It is the best general preservative of material for class-work that has yet been discovered. The peculiar qualities which confer upon it this distinction are as follows:

First.—It does not extract water from the tissues and consequently it does not shrink them. The distortion of an animal will be in direct proportion to the shrinkage of its tissues, and this, in turn to the amount of water extracted. Hence it was that our attempts to preserve such watery forms as medusæ, ctenophores, etc., with our old media were always failures; our preserving fluids dehydrated them. Formaldehyde, however, will preserve almost every form of animal life known without any distortion. Such a fact opens up possibilities for class instruction which are almost ideal.

Second.—Most of the pigments of the animal body are not extracted by formaldehyde. This quality ranks next in importance to the preceding one. Natural coloration enters so largely into our conceptions of animals that bleaching during the process of preservation is always to be deplored. With alcohol as the preserving fluid, all parts are certain to be brought to the same level of dingy yellow after a time. But with formaldehyde, we can hope to show our students the colors which actually characterized the animals during life.

Third.—It does not render tissues opaque. On the contrary it retains the transparency of the living parts, or may even add to it. Nerves are often more readily traced after preservation than during life.

Fourth.—It leaves tissues as flexible as it is possible for them to be. The natural elasticity of the parts is usually perfectly retained, and brittleness never occurs.

Fifth.—It is a very convenient reagent for collectors to use. The preserving medium is a dilute solution of the commercial article in water. A collector can carry enough formaldehyde in a bottle which will slip into his coat pocket to make several gallons of the preservative. The water used in diluting it should always be that from which the collection is made, either salt or fresh, as the case may be.

Sixth.—It is a very cheap reagent. The commercial article is imported duty free by the State University of Iowa in 100-pound lots at a cost of 40 cents per pound. When made up in a 4 per cent solution the cost of a gallon is thus only 12 4-5 cents.

We might, in fact, summarize the various desirable qualities of formaldehyde as a preserving medium as being "very close to the ideal." A reagent which preserves faithfully all natural features just as they were during life. That it is infinitely

superior to alcohol is the verdict of everyone who has thoroughly tested it. It is true that it was severely criticized soon after its introduction into America, by certain workers who failed to secure *permanent* preservation with it. In all such cases of failure the solutions employed were very weak ones. A proper strength of solution is a very important detail. A solution of 4 per cent strength—that is, one containing

Commercial formaldehyde.....	4 volumes,
Water.....	96 volumes,

is perfectly safe for most objects. Of course, stronger solutions are required for special cases, and slightly weaker ones for others.

Certain precautions in the use of this reagent require notice here:

First.—The gas is quite volatile, and the containing jar must be kept tightly sealed. If it be impossible to entirely prevent evaporation, changing the solution occasionally will answer perfectly well.

Second.—The solution being an aqueous one it is liable to freeze. This probably appears, at first, a very serious matter, because we are so used to alcohol as a preservative, and this does not become frozen.

Third.—The gas is irritating to the eyes, nose and throat. The effect, however, is merely temporary. Prolonged washing in water before a dissection is to be made will remove much of the reagent and reduce the annoyance to a minimum. Alcohol of 70 per cent strength appears to extract formaldehyde more rapidly than does water, but it is not always practicable to use it.

II. THE USE OF FORMALDEHYDE IN FIXING AGENTS.

In cellular biology the choice of a fixing agent means a great deal. All the conceptions which we build up about the cell appear to rest primarily upon the character of the reagent which was used in killing it. While we constantly seek to keep in our preparation the features of the living cell, how far short of the ideal we often fall every histologist knows. It is probable that certain recent investigations in cell structure will have to be gone over again because of too blind a faith in the fixing agents which were used.

Formaldehyde alone is not suitable for general cytological work. It has a tendency to produce a vacuation in protoplasm

which is very deceptive. It may, however, be combined with other reagents with superior results. When added to picric acid there is given one of the most delicate fixing agents yet imagined; one which appears to faithfully preserve every detail of structure, and which also permits of subsequent treatment in any desired way. Mixtures of formaldehyde, chromic acid, and acetic acid; or of formaldehyde, platinic chloride, and acetic acid are also very desirable. The principle involved here appears to be that formaldehyde may often be advantageously substituted for osmic acid in such mixtures on account of its superior penetration and the absence of a tendency to over-fixation. In all these cases formaldehyde is to be used pure, not diluted.

III. FORMALDEHYDE IN NEUROLOGICAL WORK.

I have been impelled to make a critical examination of neurological methods in connection with a certain line of investigation in which I am engaged. Of course the technique employed in the study of any nervous system is necessarily highly specialized, but the following notes have a general application. Formaldehyde may justly claim a place in neurological methods. Its chief uses are:

First.—It is an excellent hardening agent for the brain, where anatomical methods alone are to be employed. It hardens with surprising rapidity, so that after a week or ten days a fairly large brain can be thoroughly studied.

It also preserves the form and color of the several parts. Its only undesirable effect lies in the increase in volume which is given by a solution of just moderate strength.

This tendency to swell the parts may be lessened by the use of a strong solution, one containing 10 to 20 per cent of the commercial article. It has also been recommended by various workers that a mixture of formaldehyde and alcohol be used, the tendency of the latter to shrink tissues, offsetting the swelling action of the former. Messrs. Parker and Floyd believe that they have struck the proper balance in the following mixture:

95 per cent alcohol.....	6 volumes,
2 per cent formaldehyde.....	4 volumes,

in which a barely perceptible increase in the size of the brain occurs. I believe that it is well to double the strength of the formaldehyde in this mixture, and I am accustomed to do so in my own work.

Second.—Formaldehyde has an application in those methods used for tracing the course of medullated nerve fibers. All such methods, whether the original Weigert or some modification of it, are usually long and tedious, the time required frequently being some months. This length of time is often a very serious objection. Formaldehyde can be introduced in these methods for the purpose of rapidly giving firmness to the nervous tissue, and then subsequent steps may follow in quick succession. In this way the time may be reduced to ten days for the whole process.

Third.—In the study of nerve cells formaldehyde may now claim a place in the beautiful impregnation method of Golgi. The application is made in Golgi's "rapid" method, and consists in the substitution of pure formaldehyde for the 1 per cent osmic acid of the hardening mixture. The advantages resulting from this substitution may be an increased clearness of the subsequent silver impregnation, or in the slightly wider latitude of time during which hardening may occur. The physiological condition of the nervous tissue appears to be a very important factor in all Golgi work; and perhaps formaldehyde is less sensitive to these differences than osmic acid. However that may be, osmic acid in this method cannot be dispensed with. Workers should use both hardening mixtures side by side. The results attained by one will supplement those of the other in a most valuable way, thus virtually doubling the efficiency of the study as a whole.

THE NERVE CELLS OF THE SHARK'S BRAIN.*

BY GILBERT L. HOUSER.

The sharks are of the greatest interest to the morphologist on account of the many ancestral characters of their organization. The researches of recent years indicate that they represent quite well the primitive stem of the jaw-bearing vertebrates. With this fact in mind, the importance of the study of the shark's brain is at once apparent. For obvious

* The following brief notes are to be considered as in the nature of a mere preliminary communication on this subject.

reasons modern neurological investigation has been largely concerned with the mammalian brain in general and the human brain in particular. But the structures here are highly specialized, and their significance cannot always be thoroughly understood. In order to unravel the tangled threads of the complex neurological skein, the study of some primitive type of brain is an absolute necessity. The brain of the shark is the one to which we naturally turn for this purpose because of the morphological position which it occupies.

The several parts of the brain are arranged in almost perfect longitudinal series, and are well separated from each other. The *prosencephalon* is a relatively large, unpaired, globular mass. Its ventricle is imperfectly divided into lateral ventricles. A very prominent olfactory apparatus projects anteriorly. On the dorsal surface there are to be seen two slight swellings which may be taken as the anlagen of the cerebral hemispheres of higher forms. The *thalamencephalon* is narrow, open dorsally, and the choroid plexus passes in to form a thin roof. The epiphysis arises just behind this point. It is long and slender, and ends in a dilation which is attached to the membranous roof of the skull. Both the *optic lobes* and the *cerebellum* retain the primitive condition of hollow outgrowths. The cerebellum is relatively quite large, and is thrown into transverse folds. The large size is evidently related to the swimming habits of the animal. The fourth ventricle of the *medulla oblongata* is widely open. Its sides are thickened, and project anteriorly as the restiform bodies.

The microscopic structure of the shark's brain was investigated by a few of the older workers, Viault, Rohon, and Sanders requiring especial mention here. The application of silver impregnation by Golgi to the study of nerve cells has, however, opened a new era in neurology, and has made necessary the reinvestigation of every species of nervous system. While the older methods of research had brought out certain general facts about the structure of the shark's brain, it is only through the application of the Golgi method that we can hope to acquire a thorough knowledge as to its ultimate cellular structure. I will enumerate briefly the most important results which I have already reached.

In the fore-brain the nerve cells are large and very conspicuous. They are not arranged in layers, neither do they have a pyramidal form. The prevailing type presents an oblong cell

body from which three or four dendrites radiate indifferently in every direction. The dendrites do not branch very much, but there are so many of them that a very tangled complex is given.

In the mid-brain the ependyma cells are highly developed. Their processes run straight out through the whole of the nervous matter, giving a characteristic appearance to this part of the brain. The nerve cells appear to be somewhat better differentiated than in the fore-brain. Near the outer surface there are cells which send their dendrites in a tangential course. At a deeper level there are somewhat larger cells whose dendrites spread out in all directions. Still another type of cell may be found having long dendrites passing over the greater part of the distance between ependyma and outer surface.

The cerebellum has a structure which appears to foreshadow in its general plan the details of structure of a higher brain. It has a series of well defined layers, and the same layers are present in the same relations to each other as are found in the human cerebellum. There is a wide nuclear zone lying next the ependyma. A molecular layer lies next the outer surface. Between the two there is a crowded row of Purkinje cells. These cells have the familiar dendrites forming an arborization in the outer zone, but the degree of branching of the dendrites is far less marked than in the mammalian cerebellum.

The medulla oblongata exhibits a most beautifully reticulated system of fiber tracts. In this reticulum the microscope reveals neuroglia cells, processes of ependyma cells, and an occasional nerve cell. Whether the nerve cells are present except in connection with the nuclei of the cranial nerves which arise here is a fact which I have not yet determined.

Summarizing the above results, we see that mid-brain, cerebellum, and medulla oblongata foreshadow in organization the human type; but that the fore-brain does not. Coupling this fact with the suggestion to which I have already alluded as to the significance of the dorsal eminences of the fore-brain, and we have grounds for the hypothesis that the cerebral cortex proper is of secondary development.

SOME MANITOBA CLADOCERA, WITH DESCRIPTION OF ONE NEW SPECIES.

BY L. S. ROSS.

No record is to be found among the literature upon Entomostraca, of any systematic work done upon this interesting division of the Crustacea in Manitoba, or any of the provinces of Canada. The region is yet open to the student of the distribution of the group. A short stay in the province of Manitoba in June, 1895, was utilized by the author in making a few collections from the region about Portage la Prairie on the Canadian Pacific railroad, fifty-five miles west of Winnipeg. Before leaving the province some vials of alcohol were left with a resident of the town to be filled with collections. A vial was received every second week from the time of the visit until cold weather, the latest being filled October 21, 1895. One vial remained to be filled the following spring.

Collections were taken by the author from the Assiniboin river, from a deep, weedy slough which was once the channel of the Assiniboin river, from railroad ditches, and from prairie sloughs and ponds. A hurried visit to Lake Manitoba gave opportunity for a few hauls of the net among the rushes along the shore.

An examination of the material obtained shows the presence of thirty species and varieties, one of which, and possibly two, is a new addition to the list of described species.

The forms found belong to the following families:

Sididæ	1
Daphniidæ	9
Bosminidæ	1
Macrothricidæ	4
Lynceidæ	13
Polyphemidæ	1
Leptodoridae	1
Total	30

The distribution of the species is given in the following table:

ASSINIBOIN RIVER.

Daphnia pulex De Geer.
Ceriodaphnia consors (?) Birge.
Illocryptus sp ?
Chydorus sphaericus O. F. Muller.
Graptoleberis testudinaria var. *inermis*; Birge.

RAT CREEK AT M'DONNELL ON PORTAGE PLAINS.

Daphnia pulex De Geer.
Ceriodaphnia consors (?) Birge.
Simocephalus vetulus O. F. Muller.
Simocephalus serrulatus Koch.
Scapholeberis angulata Herrick.
Scapholeberis mucronata O. F. Muller.
Eurycercus lamellatus O. F. Muller.
Alona costata Sars.
Graptoleberis testudinaria var. *inermis*, Birge.
Pleuroxus procurvus Birge.
Pleuroxus excisus Fischer.
Pleuroxus sp ?
Chydorus sphaericus O. F. Muller.
Acroperus leucocephalus Koch.
Polyphemus pediculus Linn.

PRAIRIE SLOUGH NEAR PORTAGE LA PRAIRIE.

Daphnia pulex var. *pulicaria*, Forbes.
Ceriodaphnia consors (?) Birge.
Simocephalus vetulus O. F. Muller.
Simocephalus serrulatus Koch.
Scapholeberis mucronata O. F. Muller.
Lathonura rectirostris O. F. Muller.
Macrothrix laticornis Jurine.
Bunops scutifrons Birge.
Eurycercus lamellatus O. F. Muller.
Graptoleberis testudinaria var. *inermis*, Birge.
Dunhevedia setiger Birge.
Pleuroxus denticulatus Birge.
Pleuroxus procurvus Birge.
Pleuroxus sp ?
Chydorus globosus Baird.
Chydorus sphaericus O. F. Muller.
Alonopsis latissima var. *medir*, Birge.
Acroperus leucocephalus Koch.
Polyphemus pediculus Koch.

DEEP WEEDY SLOUGH AT PORTAGE LA PRAIRIE.

Sida crystallina P. E. Muller.
Daphnia pulex DeGeer.

Ceriodaphnia consors (?) Birge.
Ceriodaphnia reticulata Jurine.
Ceriodaphnia acanthinus n. sp.
Simocephalus vetulus O. F. Muller.
Scapholeberis mucronata O. F. Muller.
Lathonura rectirostris O. F. Muller.
Bosmina longirostris O. F. Muller.
Eurycercus lamellatus O. F. Muller.
Alona quadrangularis O. F. Muller.
Pleuroxus denticulatus Birge.
Pleuroxus procurvus Birge.
Chydorus sphaericus O. F. Muller.
Camptocercus rectirostris Schoedler.
Polypheumus pediculus Linn.

LAKE MANITOBA.

Bosmina longirostris O. F. Muller.
Chydorus sphaericus O. F. Muller.
Leptodora hyaulina Lilljeborg.

CERIODAPHNIA ACANTHINUS, N. SP.

The body is large, round, with the valves of the shell forming a well developed posterior spine. The head is separated from the body by a very deep depression. Head is low, small, rounded in front of the eye, sinuous above and angled between the eye and the antennules; the lower margin is nearly in a line with the lower margin of the valves of the shell.

The shell is very strongly reticulated with small, very sharply-marked hexagonal reticulations measuring about .016 to .021 mm. across. Small sharp spines project from the angles of the reticulations, many at nearly right angles with the surface of the shell. In the possession of these spines this species closely resembles *C. setosa*, Matile. No spines were seen on the rounded front of the head as are usually present in *C. lacustris*, Birge. The dorsal margin of the shell is arched, curving gradually into the posterior margin.

The posterior spine of the shell may be near the dorsal margin, or one-third the distance from the dorsal to the ventral margin. When the spine is situated low the posterior shell margin above is slightly concave. The spine is as well developed as in *C. lacustris*, Birge, and often ends in blunt teeth, but is not divided into two parts at the end as is sometimes the case in that species. The posterior margin of the shell curves gradually into the strongly convex ventral margin. The fornices are greatly developed, extending almost the width of the shell. They are almost as broad but are not so sharply angled as in *C. lacustris*, and do not end in sharp teeth.

The antennules are short and thick, reaching to or a very little beyond the angle behind the eye. Setae are present toward the distal end. The antennae are long and rather slender; the setae reach nearly to the posterior margin of the shell.

The post abdomen is of moderate size, slightly tapering toward the end and is armed with nine to eleven strong recurved spines of nearly equal size, except the first and last, which are smaller. The anal claws are long,

curved, and denticulate on the inner side with minute teeth of two sizes. The teeth of the basal two-fifths of the claw, some forty or fifty in number, are two or more times longer than those of the distal portion.

The eye is of moderate size, situated near the margin of the head or back a short distance from the margin. The lenses do not project far from the eye pigment. The pigment fleck is small, rounded, and situated above the posterior portion of the eye at a distance approximating half the diameter of the eye.

In general shape the species resembles *C. rotunda*, Straus. The posterior spine is not as near the dorsal margin as Kurtz figures it in *C. rotunda*, but is in nearly the same position as in a specimen examined of that species identified by G. O. Sars of Norway. The reticulations are as distinct and the double contoured markings (due merely to depth of reticulated areas) mentioned by Herrick and used in his key, are fully as prominent as in *C. rotunda*.

The reticulations and the minute spines on the surface of shell are very like those described and figured in *C. setosa* by Matile. The measurements of *C. setosa* are but little over half those of *C. acanthinus*. Matile's description of *C. setosa* gives the length .42 to .54 mm. and the height .27 to .36 mm., while *C. acanthinus* measures from .80 to 1. mm. in length, and .70 to .77 mm. in height. The head of *C. acanthinus* is larger and extends nearer to a level with the ventral margin of the shell. Some specimens of *C. reticulata* taken from the same slough at the same time have the reticulations nearly as distinct as in *C. acanthinus*, and also possess minute spines upon the surface of the shell. The two species are distinct, however, because of differences in the shape of the body, and of the difference in the armature of the anal claws.

The males were not seen. The mature females measure from .80 to 1. mm. long and .70 to .77 mm. high. Found in abundance in a weedy slough in late May, 1896, at Portage la Prairie.

NOTES ON SOME OF THE SPECIES.

Sida crystallina.—Was taken only from a deep weedy slough at Portage la Prairie.

Ceriodaphnia reticulata.—Was in a bottle sent in May, 1896, from the slough at Portage la Prairie. The specimens have the reticulations very sharply marked. Some show numerous short spines at the angles of the reticulations. The number of spines on the anal claw varies somewhat. This species was found with *C. acanthinus*. It differs from the typical *C. reticulata* in the distinctness of the reticulations and in the presence of spines on the shell in some individuals.

Ceriodaphnia consors.—Numerous specimens were found at various places which are with much hesitation referred to this species.

Scapholeberis angulata.—Was taken only in small numbers, a few being found in Rat Creek on Portage Plains.

Daphnia pulex var. *pulicaria* —Was found in small numbers in a prairie slough near Portage la Prairie.

Simocephalus daphnoides (?).—The body is robust, with greatest height a little behind the middle. The head is rounded in front and has no spines. Lower margin of the head is slightly concave, straight, or even slightly convex to the base of the short beak which may project at nearly a right angle to the lower margin of the head. The head is separated from the body by only a very slight depression. Depth of the head in one specimen is .77 mm., length from the posterior margin of the base of the antennæ .52 mm. The head has a daphnia-like appearance. The ventral margin of the shell has few very short blunt teeth. The posterior margin from short blunt posterior spine toward dorsal margin has teeth better developed than those on the ventral margin. The dorsal margin teeth continue forward a short distance. The posterior spine is very short, blunt, armed with short teeth and is situated little above the middle of the posterior margin.

The eye is of moderate size, situated near the front of the head, or at a short distance from the front, and at a distance from the lower margin equalling one-half the diameter of eye, or at a distance slightly greater than diameter. Pigment fleck is irregular in shape; elongated, rhomboidal and oval forms were seen. Pigment fleck is small, situated near the posterior margin of the head.

Specimens measured vary in length from 2.04 mm. to 2.53 mm. in depth from 1.20 mm. to 2.04 mm.

The description of *S. daphnoides* as given by Herrick in *American Naturalist*, May, 1883, and in *Entomostraca of Minnesota*, is rather brief. Herrick states that the form is found only south of the Tennessee river; but a comparison of specimens taken in Manitoba, with the original drawings and brief description in the *American Naturalist*, makes it probable the form is found even in that northern province.

Lilljeborg's "*Crustaceis*" published in 1853, gives drawings of *S. vetulus*, with the lower margin of the head as nearly straight as in the figures by Herrick, and the general outline of the body almost as daphnia-like in appearance.

Eylmann in the "*Berichte der Naturforschenden Gesellschaft zu Freiburg*" Zweiter Band, Drittes Heft, published in 1886, figures the lower margin of the head of *S. vetulus* straight to the short beak, and the body with greatest height at the middle.

A specimen of *S. vetulus* identified by G. O. Sars of Norway, and examined by the author, has the lower margin of the head straight to the very short beak, and the eye situated at a distance from the lower margin, equal to about one-half the diameter of the eye.

Herrick says in his description that the curved spines present in the other species at the caudo-ventral angle of the shell are absent from *S. daphnoides*. If this be constant it seems to be the only character not possessed by *S. vetulus*.

The specimens taken in Manitoba, and also in Iowa, vary in size and shape of the head and of the body,—there are such grades of variation, and authors figure such differences of form in *S. vetulus* that it seems very probable that *S. daphnoides* is merely an extreme form of *S. vetulus*.

Bosmina longirostris.—Found in only two collections: one from Lake Manitoba and the other from a slough at Portage la Prairie.

Macrothrix laticornis.—This species was met with only in a shallow prairie slough, and was by no means abundant.

Bunops scutifrons.—This beautiful species was found rather frequent in the shallow prairie slough at Portage la Prairie.

Ilicryptus sp?—A few shells and one individual of this genus were taken from the Assiniboin river. The species is probably *longiremis*, Sars.

Alona quadrangularis; *Alona costata*.—There is some question as to the identification of these two species. Only a single individual of each was found. The specimen that may be *Alona costata* is not strongly striated, but other characteristics agree with descriptions of this species.

Graptoleberis testudinaria var. *inermis*.—Although taken at three different places this species was rare. A few individuals were found in Rat creek, one in the collection from the Assiniboin river, and one individual, and a few shells from a prairie slough.

Dunhevedia setiger.—This species is apparently rare during the season of the year the collections were taken, as few individuals were found. They were taken from a prairie slough. Birge, in his "List of Crustacea Cladocera from Madison, Wisconsin," mentions the fact of *D. setiger* being one of the rarest of Cladocera in that region, but that in the month of August he found them in immense numbers, both males and females.

Pleuroxus sp ?.—The shell is long and low, in some specimens evenly arched from the posterior dorsal angle to a point a little in front of the brood chamber, from which the curve is flattened slightly to a distance including the basal third of the long sharp rostrum. In others the dorsal margin is evenly arched from the postero-dorsal angle to the rostrum. The head is small, high, with the long, sharp, curved rostrum far from the anterior margin of the shell, parallel with it, and reaching nearly to a line with the ventral margin of the shell. The ventral margin is straight for two-thirds of its length from the anterior margin; the remaining third curves gently upward and has a single small tooth pointing backward, a little in front of the sharp curve into the posterior margin. The ventral margin has long pectinated setæ, becoming shorter toward the posterior end of the shell. The anterior margin has setæ for a short distance from the ventral margin. A blunt posteriorly directed projection is formed by the postero-dorsal angle of the shell.

The post abdomen is long, slender, truncate, tapering toward the end. The posterior edge is slightly concave, and is armed with eighteen to twenty or more small spines; the spines at the distal end of the series are much the longer and stronger. Anal claws are pectinated, long, and slightly curved. The second basal spine is longer than the first.

The eye is of moderate size. Pigment fleck is about one-half as large as the eye, and is situated one-fourth the distance from the eye to the end of the rostrum. The antennules are cylindrical, with setæ at the end, and a lateral seta. Length of antennules about equals the distance between the eye and the pigment fleck. Antennæ are short, small, with long setæ.

The specimens do not agree in all respects with the description given by Birge of *Pleuroxus gracilis* var. *unidens*, but do agree in many points. The largest specimen found measures .60 mm. in length by .38 mm. in height; another measures .60 mm. long and .33 mm. high. Birge gives a measurement of .85 mm. by .46 mm., and states that the species is the largest yet seen. The original description of *P. gracilis* var. *unidens* states that, "the striation is very plainly marked." The specimens found by the author are only very faintly striated, and that most distinctly at the anterior part of the shell, where the lines of striation are approximately parallel to the anterior margin. The larger part of the surface is free from markings, either striation or reticulation as far as could be observed. The

shell is more arched dorsally than *P. gracilis* is figured by Matile. Birge's description of *P. gracilis* var. *unidens* says: "The upper posterior angle is prolonged into a projection, quite characteristic, seen, I believe, in no other species." In the specimens found there is a slight projection at the angle, but not so pronounced as figured by Birge and by Herrick. The lower posterior corner is rounded and has a small tooth anterior to it as in *P. gracilis* var. *unidens*.

It seems improbable that the differences between the specimens and the description and drawings of *P. gracilis* var. *unidens* should fall within the range of variation of a variety. The males were not seen. Collected in small numbers in June, 1895, from a shallow slough and a small creek.

Pleuroxus excisus.—Only one or two individuals were observed. These were taken from Rat creek, a sluggish stream flowing into Lake Manitoba.

Alonopsis latissima var. *media*.—The specimens resemble the species described by Birge, but have some points of difference. Birge's description is as follows: "Rostrum prolonged, and shell sharp, somewhat quadrangular in shape, marked by stræ. The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave and has long plumose setæ. The front margin is strongly convex. The post abdomen is long and slender, resembling that of *Camptocercus*, and is notched at the distal extremity; it has two rows of fine teeth and some fine scales above them. The terminal claws are long, slender, with a basal spine in the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense hairs. The antennæ are small and have eight ($\frac{3}{11}$) setæ and two ($\frac{1}{10}$) spines. The labrum resembles that of *A. leucocephalus*, but is slightly prolonged at the apex. The intestine, cæcum, and color resemble those of *Acroperus*. There is a trace of a keel present on the back."

Herrick's statement, in part, is as follows: "The specimens seen in Minnesota resemble this species [*A. latissima* var. *media*] very nearly, apparently, but there are some differences. The terminal claw has an increasing series of spines to the middle; there seems to be no lateral row of scales beside the anal teeth; the abdomen is rather broad at the base and narrows toward the end. The shell is not square behind. The

lower margin has a few long hairs anteriorly which are followed by a series of teeth, and in the concave part a somewhat longer set to a point just before the lower curved angle."

In most respects the Manitoba specimens agree more nearly with Herrick's description than with Birge's. A few points of difference are noted. In the Manitoba specimens a few long hairs are present on the lower margin anteriorly, then at a little distance posteriorly from the hairs are short, sharp bristles, hardly heavy enough to be called teeth, becoming largest on the concave part of the margin. In one specimen the end of the abdomen is deeply cleft, the posterior lobe bearing four very strong teeth of nearly equal size. Herrick says that hexagonal reticulations are seen upon the shell of the embryo yet in the brood sac. In several sexually mature females observed faint reticulations are present, more distinctly seen near the ventral margin.

Polyphemus pediculus.—This species was found to be quite common in the Portage Plains region. It has not been reported from Iowa. Although reported from Georgia it seems to be more commonly found in the north.

A NEW SPECIES OF DAPHNIA, AND BRIEF NOTES ON OTHER CLADOCERA OF IOWA.

BY L. S. ROSS.

A few collections taken from West and East Okoboji Lakes and Spirit lake in June, and from the sloughs of the Des Moines river in the fall of 1896, have added six more species to the list of Cladocera in the state, as given in the "Proceedings" of the Academy for 1895. Five of the species are common to the country, and one is an hitherto undescribed species of *Daphnia*. A few individuals of a form of the difficult genus *Bosmina* were found which may be the young of *Bosmina longirostris*, O. F. Muller. If not the young of this species then seven instead of six species will be added to the list.

The species taken the past summer and fall not reported in the "Preliminary Notes" are:

Daphnia pulex De Geer.

Daphnia hybus n. sp.

Bosmina longirostris O. F. Muller.

Pleuroxus exiguus Lilljeborg.

Alona guttata Sars.

Graptoleberis testudinaria var. *inernis*, Birge.

This gives a total list of thirty-one species of Cladocera reported from the state.

DESCRIPTION OF A NEW SPECIES—DAPHNIA HYBUS.

The body is large, robust, with a prominent keel-shaped projection on the dorsal margin immediately anterior to the brood chamber; the projection rises at a rather low angle anteriorly, approximately 20 to 25 degrees, but falls posteriorly at a greater angle, approximately 40 to 50 degrees. It is present on the ehippial females and also on those bearing summer eggs. The measurement of the projection on one specimen gave the length of .14 mm. and a height of .05 mm. On one specimen a second projection is present, located on the dorsal margin above the base of the antennæ. Measurement showed its length to be .28 mm. and height, .09 mm. In yet another specimen the projection above the base of the antennæ is evident under the shell, and it would apparently have become external at the next moult. The dorsal margin of the shell is convex, minutely spined from the posterior shell spine nearly to the front of the brood chamber. In one or two specimens the spines were not observed. The ventral margin is strongly convex, and is armed with small spines about one-half the distance forward from the posterior shell spine; the margin is sinuous below the posterior spine, which is situated usually about half way between the median line of the body and the dorsal margin, but sometimes nearly on the median line. Spine is straight, slender, directed slightly upward, .77 mm. long in one specimen, and has scattering, feeble spinules.

The head is broad, not helmeted, strongly arched dorsally, and is not separated from the body by a depression. The ventral margin of the head is slightly concave below the eye, midway between the front of the head and the end of the long beak. Depth of the head is about two times the length from the base of the antennæ.

The eye is of medium size, with few prominent crystalline lenses, and is situated at a distance from the front of the head, about equal to the diameter of the pigmented portion. Distance of the eye from the posterior margin of the head is little greater than diameter of the eye. The transparent orbit reaches to the front of the head. Pigment fleck is small, not

more than one-fourth the diameter of a crystalline lens. It is situated near the median line, about midway between lower half of eye and the posterior margin of the head.

The antennæ are moderately developed, the setæ reaching nearly to the posterior margin of the shell. The first joint of the setæ is longer than the second.

The post abdomen is rather slender, tapering toward the posterior end, and is armed with about fifteen strong curved spines, which become gradually smaller anteriorly. Anal claws are pectinated, and armed with a strongly developed basal comb of two groups of spines of about six in each group. Spines of upper group much smaller than those of lower. Processes of the post abdomen are separate, first longest, not haired, second and third haired.

Some measurements are as follows:

Length	2.30 mm.	Height	1.32 mm.
Length	2.00 mm.	Height	1.27 mm.
Length	2.77 mm.	Height	1.85 mm.
Depth of head	1.00 mm.	Length of head .....	.46 mm.
Depth of head	1.07 mm.	Length of head .....	.50 mm.
Depth of head .....	.88 mm.	Length of head .....	.44 mm.
Posterior spine, .70 mm. to .77 mm.			

The species is evidently very closely related to *D. minnehaha*, Herrick, and may have only varietal rank.

The general outline of the body of old females is similar to that of *D. minnehaha*, including the angle or projection in front of the brood chamber. None of the specimens examined showed any evidence of teeth upon the dorsal angle as are present in males and young females of *D. minnehaha*. No broad projection on the dorsal margin above the base of the antennæ is mentioned in descriptions of *D. minnehaha* or figured in the drawings. The beak is longer in *D. hybus*, and is slightly curved toward the end. The eye in *D. hybus* is farther from the front margin of the head, and the lenses much larger than are figured in *D. minnehaha*. The posterior spine is longer in *D. hybus*. In *D. minnehaha* "the anal spines are eleven or more in full grown females, and decrease only moderately upward." In *D. hybus* the anal spines vary from about fifteen to nineteen. Herrick says of *D. minnehaha*: "The size is small but variable; 1.8 mm. is a common measurement." In addition the following measurements are given: "Female, length, 1.44 mm.; spine, .33 mm.; head, .26 mm.; depth of

head, .46 mm. Ephippial female, length, 1.64 mm.; spine, .20 mm.; head, .35 mm.; depth of head, .80 mm.; greatest depth of shell, .94 mm."

A comparison with the measurements given of *D. hybus* shows the latter to be a much larger form, in some instances approaching a length and depth double that of *D. minnehaha*.

In the "Preliminary Notes on the Iowa Entomostraca," published in the proceedings of the Iowa Academy of Sciences, vol. III, I followed the classification of Birge and Herrick, and placed *Daphnia retrocurva*, Forbes, in the list as a variety of *Daphnia kalbergiensis*, Schoedler. At that time I had not seen the original description of either species.

In Forbes' description of *D. retrocurva* first published in the American Naturalist, vol. XVI, page 642, August, 1882, he says: "The shell is reticulate and its spine long and straight, there is no macula nigra, and the caudal claws have a row of teeth at their base." The row of teeth referred to is the accessory comb. The teeth of the comb are often very small and hard to distinguish, but in all the specimens of *D. retrocurva* I have examined they are present. In "Die Cladoceren des Frischen Haffs," published in 1886, Schoedler gives his original description of *D. kalbergiensis* under the name *Hyalodaphnia kalbergiensis*. The statement in regard to an accessory comb is: "Die Schwanzklauen sind ohne secundäre Zähnelung."

The presence or absence of the accessory comb is recognized by systematists as a specific character. Hence *D. retrocurva* cannot be ranked as a variety of *D. kalbergiensis* but as a distinct species. In his "Notes on Cladocera Crustacea at Madison, Wis.," Birge suggests the propriety of separating the American forms from the European *D. kalbergiensis*, because of the pectinated caudal claw, and says: "This would probably bear the name *D. keruses*, Cox."

The note by Cox in the American Monthly Microscopical Journal of May, 1883, in which the name of *D. keruses* is proposed for this remarkable form is an incomplete description and the illustration is not accurate. The description of the species with the proposed name *D. retrocurva* was published in August of the preceding year.

It is evident that the form described under the names *D. retrocurva* and *D. keruses* is not a variety of *D. kalbergiensis*, but is species *D. retrocurva*, Forbes, of which *D. keruses*, Cox, is a synonym.

NOTE.—Since writing the above upon *D. retrocurva* the "Revision of the Genus *Daphnia*," by Jules Richard of Paris, has been published, in which *D. retrocurva* is recognized as a species because of pigment-spot and caudal claw characters, and *D. keruses* as a synonym of it.

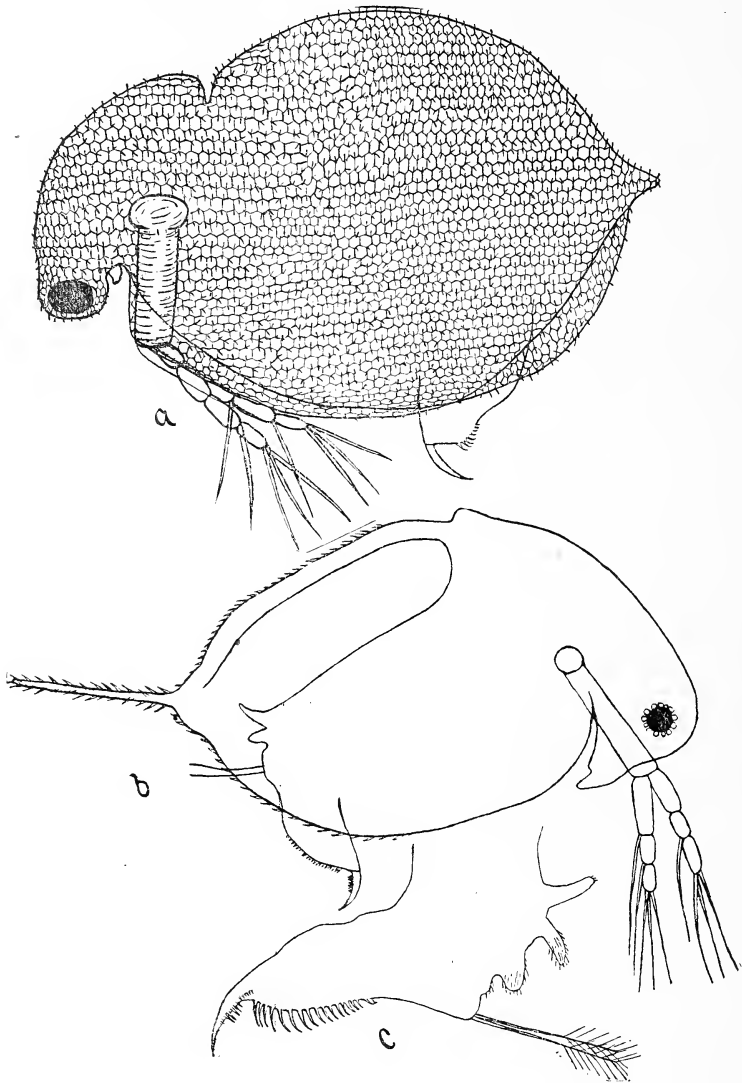


Fig. 5. (a) *Ceriodaphnia acanthinus*, n. sp. (b) *Daphnia hybus*, n. sp. (c) *Daphnia hybus*, post abdomen.

NOTE—The reticulations in a are somewhat too regular.

THE ILLINOIS BIOLOGICAL STATION.

BY L. S. ROSS.

In Europe there are twenty-seven or more marine biological stations, one in Japan and five in the United States. The attention of biologists has been given mostly to the study of marine life, but some of the inland scientists are taking to the fresh water, leaving the marine life to be salted down by those near at hand. But it is only of late years that a few zoologists have bethought themselves to halt in their rush to the marine stations and cast a microscopic squint at the myriads of forms dashing and crowding through the water of the lakes and streams, and even inviting the hauls of a net in order to relieve the pressure of an overabundant surplus of population.

Germany possesses two fresh water biological stations, one on Lake Plön in the northern part of the country, and the other upon Müggel lake, near Berlin. There is one station in France and a peripatetic one in Bohemia. The Allis private laboratory at Milwaukee was the first fresh water station in this country. The University of Minnesota had for several years a summer station at Gull lake, and for the past two years the University of Indiana has maintained a summer school of biology at Turkey Lake. The Michigan Fish Commission and the University of Michigan have been studying the waters of the state for several years with special reference to fish culture.

The station established at Havana, Ill., on the Illinois river, is the first fresh water university biological station with adequate equipment and working force in the country, and is the only station in the world having as its subject of investigation the life of a river system. The region about Havana has long been noted as a sportsman's paradise because of the wide bottom lands of the river and the many sloughs and swamps; and it has proved to be equally the paradise of hunters of water fleas and the like more minute game than water fowl. The amount of microscopic animal life of the water is much more

in individuals than in any other water in the world examined to determine quantity. And the number of forms of life is nearly twice as great as that in an equal amount of water from the great lakes or from the lakes of northern Germany.

The station is located at the foot of Quiver lake, a sheet of water separated from the channel of the river by a low bar, about two miles up the river from Havana. A rented house-boat was used for two years from the time the station was opened in the spring of 1894. Last spring the laboratory was moved into a new boat specially designed and built for the station at a cost of \$1,260. The new boat has a deck 20 by 60 feet, on which is a cabin 16 by 56 feet, divided into an office for the laboratory staff, a main laboratory with a long tank and sink, shelves and tables for fifteen students, and a small kitchen. The laboratory equipment includes microscopes, reagents, etc., necessary for microscopic work; nets, dredges and seines for collecting; and working libraries. Three or four row boats belonging to the station are at the disposal of the workers. Besides these the station owns a 25-foot steam launch licensed to carry seventeen persons.

One of the lines of work receiving especial attention is the determination of the plankton of the river, that work being done by the superintendent of the station. Besides the principal station there are seven sub-stations where the plankton is taken at stated intervals through the year. To collect the plankton a certain amount of water is pumped into a net of the finest silk; then careful determination of the quantity, species, and even numbers follows the collecting.

The station has received for its support during the past two years the sum of \$10,400 from the following sources:

Appropriation April, 1894, from the University of Illinois	\$ 1,800
Appropriation by last legislature for two years, expiring July 1, 1897: Equipment	2,500
Running expenses, \$3,000 per year	6,000
Income from fees	100
Total	\$ 10,400

Only a small number of students can be accommodated at present, but it is the earnest desire of the director, Dr. S. A. Forbes, to enlarge the facilities sufficiently to establish a summer school of biology for the teachers of the secondary schools of the state.

Is it not possible for Iowa to organize and conduct a station similar to that supported by the state of Illinois? Perhaps a

thorough investigation of the situation, and careful thought, might suggest some plan more feasible for our state than that followed in our sister state. Illinois has a state laboratory of natural history that is studying the life of the state. We have no such authorized laboratory. But we have our State university, our Agricultural college, and other colleges broadcast over the state whose scientists are interested in biological problems, and who would certainly agree that the study of the life in our own lakes and streams, and the solving of oecological problems of our own fauna and flora are of paramount importance. Some work is being done along these lines by members of the teaching forces of the various schools. But more wide-reaching and better results could be obtained by organized effort. The life of our lakes and streams is comparatively unknown.

Such a station could be made of great value to the educational interests of the state. Provision could be made for a summer school of biology, where students could study our common every day forms of life in the midst of their activities. Not all in regard to an animal or plant is learned by cutting up an alcoholic specimen. The station should have a course of study so arranged that a student from any college in the state upon taking it would receive credit for it as actual college work. If he is far enough advanced to conduct original investigations let him receive credit for work done. Another course should be arranged that would bring the station more closely in touch with the broad educational interests of the state; that is, a course for the benefit of the public school teachers, a course supplying more directly the needs of science teachers over the whole state.

If the colleges of the state would combine in agreeing to accept work done by their students at the station during the summer under competent direction, as college work, it would encourage some to accept of facilities which may now be beyond their reach. And the colleges might do more; some might equip and support a table at the station for the most worthy students desiring to take advantage of the opportunity.

The scientific and educational possibilities of such a station are many. If financial possibilities were as many and as bright as the educational, then a biological station in Iowa would be easy to found. But how could it be founded and maintained without money? And under the control of what body should

it be? These are questions harder to answer. The first, however, is really not hard to answer. Financial support is a necessity first and other things follow. Much valuable work may be done without very expensive apparatus, but all apparatus costs something. Perhaps there is no method but that of appealing to the state to lay the foundation by an appropriation, then perhaps some of the superstructure could be erected from fees. As an answer to the second question, regarding the control of the station, one that offers itself is that the State Academy of Sciences should have control by whatever means seemed most desirable.

NOTE ON PROBABLE LIFE HISTORY OF CREPIDOD- ERA (EPITRIX) CUCUMERIS, HAM.

BY F. A. SIRRINE.

During the winter of 1894 and 1895 a trouble known as "Pimply potatoes," among potato growers, was brought to our attention. As the trouble appeared to be some skin disease, it was turned over to Mr. F. C. Stewart, the mycologist. At the time he came to no definite conclusion as to what the trouble might be. Early in the fall of 1895 Mr. Stewart obtained a quantity of "Pimply potatoes" for microscopic examination. It was found that the pimples covered what appeared to be a brown "sliver" in the flesh of the potato. This "sliver" proved to be a tube lined with broken starchless cells, the starch grains usually occurring free within the tube. Our natural conclusion was that the trouble was caused by the puncture of some insect and that the pimple resulted as an effort of the growing potato to heal the puncture. No trace of castings could be found within the tube, hence it appeared that the tube was not the result of larval mining, nor could it have been made for the deposition of an egg, for in such a case the tube would have shown larval castings. Thus it appeared as if the puncture must be the work of some "snout beetle," or of some hemipterous insect.

A close watch for the depredator was maintained during the past summer. I had my eye on the adult of a new seed stalk weevil *Centorhynchus seriesetosus* Dietz, of kale, turnip and cabbage.

On July 7th Mr. Stewart found a small thread-like white worm, about one-sixth of an inch long, burrowing into potatoes. He also found small white bodies in the soil around the potatoes. The white bodies were found to be pupæ of some of the flea beetles. They were bred, issuing in about eight days as adult *Crepidodera cucumeris*. About two weeks after the grubs were found mining the potatoes they issued as adult beetles and proved to be *Crepidodera cucumeris*.

There is a leaning to the theory that the potato flea-beetle is double brooded in this section, Long Island. I think that this is based on the fact that the beetles appear quite numerous in April and early in May on plantain and various other weeds. I have seen no evidence of their pairing at this season—in fact they were not observed pairing until June. Furthermore they were very destructive to potato and tomato vines the past season from the time the plants came up until the middle of June, at which time the beetles commenced to diminish in numbers. From the middle of July until August they appeared again in such numbers that they soon made the potato fields appear as if a hot wind had struck them.

A close watch was kept for signs of another brood after the July brood. No signs of pairing were noticed. The adult beetles appeared to gradually disappear, until late in October scarcely a single beetle could be found.

As the facts stand there is probably but one brood of the potato flea-beetle a year. The eggs are probably dropped during the month of June to the ground from whatever plant the adults are feeding upon. The larva hatch and work their way to the roots and tubers of the plants upon which they feed. The pupa stage is passed in a naked state in the surrounding soil. The adults issue in July and August, feeding awhile, then scatter to hibernate. They come out early the following spring, feed on various plants until the latter part of May, or until June, at which time they begin to pair and deposit their eggs.

The larvæ are only about one-sixth of an inch long. They are provided with three pairs of true legs and a single anal leg. They have a peculiar habit of resting at nearly right angles to the object on which they are feeding. They will remain in this position even after the root or tuber upon which they are feeding has been removed from the ground. They rarely mine more than the length of the body into the root or tuber. These

mines are barely large enough to more than admit of the larva getting into them—in fact it requires considerable effort on the part of the larva to back out of one of these mines, when disturbed.

It was found that some varieties of potatoes contained more pimples than other varieties. It was also found that varieties which did not contain many “pimples” often contained as many “slivers” or tubes as the more “pimply” varieties. At the same time potatoes in all varieties could be found with “slivers” where no pimples had been formed. Whether “pimples” are formed only at certain stages of growth of the potato, or whether some varieties form “pimples” while others do not, is still a question.

CONTRIBUTIONS TO THE HEMIPTEROUS FAUNA OF IOWA.

BY HERBERT OSBORN AND E. D. BALL.

I. ON THE LIFE-HISTORY OF JASSIDÆ.

(With descriptions of new species and a review of the genus *Deltoccephalus*.)

In various papers published during the past five years the senior author has called attention to the injuries caused in grass lands and pastures by the numerous species of Jassidæ, which swarm, often by millions to the acre, upon various species of grasses.

In these papers it has been shown that the loss, though seldom noticed, must be really enormous, and that by the use of the tar pan or “hopper-dozer” the insects may be to a great extent destroyed. Further than this, however, our knowledge has been too meager to furnish a certain basis for remedial measures. It is true studies were made of a few species and some facts learned as to their life-history which warranted the belief that burning, mowing, etc., might be of service, but still so much remained unknown regarding even the most common species, that there seemed a necessity for a more exhaustive study. At the beginning of the present season (1896) a study was planned, the essential features of which were: First, a determination of the life histories of as many as possible of the species known to feed upon grasses. Second, the determination of the range of

the food plants for each species, especially in the larval stages. Third, the collection of all species occurring on grasses and their careful identification with a close study of the specific limits of each, as a basis for further life history studies.

Any facts suggestive of successful treatment have been carefully noted, and suggestions as to treatment of individual species made, but it has been deemed essential in this study to hold in reserve general conclusions as to treatment and to gather, first, all facts possible bearing on the life and habits of the species. These will undoubtedly furnish a scientific basis for economic treatment.

Insectary studies have consisted in rearing, as far as possible, all species in breeding cages, consisting of glass globes or netted frames over grass in large pots, along with continuous field study, the one as check to the other. In the investigation some sixty species have come under observation as grass feeders, not to mention some sixty more referred to other food plants, and their study has involved the examination of many thousands of individuals in all stages.

Of a number of species we are able to present sufficient details of life history to warrant positive conclusions, while of others the record is yet too fragmentary to be more than a starting point for future work.

While this study was undertaken primarily with reference to its economic aspects, and this phase has been dealt with particularly in a paper, duplicating this in part, to be published in bulletin 34 of the Iowa experiment station, so much matter of a technical nature has been accumulated which seems of importance in the systematic study of this group that it has been deemed desirable to publish it, with full technical descriptions of new species, where it will reach students of systematic entomology, and those interested in the biological questions discussed.

We have as a basis for work in this group, aside from the large mass of material collected in Iowa, types of all the Homoptera described by Mr. E. P. VanDuzee as well as the entire collection of Hemiptera which he made, and which formed the basis for his numerous contributions to American Hemipterology.

The college collections contain, further, a large amount of material in Hemiptera from Colorado, South Carolina and Georgia collected by Morrison; from New Mexico, Arizona, California and the northwest, collected by Wickham; from Mexico, collected by Osborn and Townsend, besides numerous smaller series received in exchange or for determination. Also series of European species, embracing representatives of a large proportion of the genera. Also some exotic material from the Bahamas, West Indies, etc.

The plates are photo-reproductions of drawings made by Miss Charlotte M. King, under personal direction and supervision of the authors.

It has not been our purpose to prepare a full list of species, but only to include such as we have studied. We have followed in arrangement, however, the "Catalogue of Jasoidea," by Mr. E. P. VanDuzee, and that catalogue may be consulted for additional references, synonymy and bibliography.

Types of the new species are deposited in the National museum.

Some of the results which seem to be general in nature may be mentioned here.

The species of Jassidæ have, as a rule, a decided limitation as to food plant, usually holding closely to one species of plant, almost invariably limited to one plant for breeding, but feeding more indiscriminately in maturer stages.

So far as known, all the species deposit eggs upon the stems under the leaf sheaths or in the leaves of the plants used as food.

There is a wide difference in life-histories, some having one brood, the majority of the grass-feeding species two, and still others three in a season, and the successive stages occurring at widely different times.

Except in the case of adult hibernation the ordinary life of a brood of adults does not exceed two months, and for the individuals of a brood rarely over one. The males appear a week to ten days before the females and disappear as much earlier. In general, one brood of adults will have disappeared before the larvæ of the next have matured, so that individuals collected at any time may be referred with assurance to a particular brood.

It follows also that eggs for each brood are deposited within a limited time and that a period may be defined during which all eggs of a given brood for a given species will have been deposited, and during which time measures for their destruction may be applied.

Observations were made to ascertain whether simply cutting the grass and leaving it in the field would prevent hatching, and in no case were eggs observed to hatch from stems cut green. Part of the stems from a plant in which eggs were fully developed were cut and left to dry. The second day after the eggs hatched in the uncut stems but no larvæ issued from those that were cut and, on examination, the eggs were found to be crushed and distorted from the shrinking of the plant tissues and by the curling of the edges of the sheaths in drying. Even if hatched they would have been unable to escape from the rigid incurved edge.

It has been learned that the larvæ present definite characters which are of specific, and in some cases generic, value. These, along with what prove to be constant characters in large series of adults, enable us to combine some forms hitherto considered

as distinct species, and also to separate as distinct some forms hitherto included with other known species.

Colorational characters in certain genera are of very little value, since it is found that summer broods and species occurring in shaded localities are pallid or unicolorous, while autumn broods or exposed individuals assume darker and more definite markings, often varying to black.

Another feature of considerable interest and of value in the discrimination of species is presented in the fact that for a number of species there are distinct long and short winged forms with consequent variations in venation (usually given generic importance) the long winged condition apparently associated with a migrant habit.

The grasses which have been more particularly under observation during the season and which seem to have each its particular jassid fauna, are: Blue grass (*Poa pratensis*), *Andropogon scoparius* and *provincialis*, *Elymus canadensis* and *virginicus*, *Bouteloa hirsuta* and *cutipendula*, *Stipa spurea*, *Spartina cynosuroides*, *Sporobolus hookeri*, *heterolepis*, *asper* and *cryptandrus*, *Chrysopogon nutans*, *Muhlenbergia racemosa*, *diffusa* and *sylvatica*, *Bromus ciliatus* and *purgans*; also a number of annuals, especially the *Panicums* and *Setarias*.

A statement of the known host plants accompanies the discussion of each species.

TETTIGONIA BIFIDA SAY.

Journal Acad. Nat. Sci., Phila., IV, p. 313, 1831; Comp. Writings II, p. 387, 1869.

This is a rather handsome little species, and its range of food habit seems to be more restricted than many of the others, it being found only on blue grass in shady places. The latter restriction confines it to wooded pastures, where it is perhaps almost as common though less universal than *inimicus* in open pastures.

The adult is about six millimeters long, of greenish color, with circular alternate bands of black and white on the head and pronotum parallel to the border. The wings have seven black stripes, the outer one forking near the middle.

Adults are first recorded for July 11th, and were most abundant July 14th, becoming gradually less numerous till the first of September, when they disappeared. While egg deposition must occur during July or August it has not been observed.

The larvæ observed July 2nd to 20th were about half the length of the adults, fully as broad, with the surface of the body

of a powdery white appearance. The head is large, broad and deep, much inflated, almost round in front; eyes dark; wing pads broad and short; the abdomen inclined to be carinate dorsally.

They are decidedly different from the larvæ of any other species of *Tettigonia* studied in the much shorter body, a fact which would seem to indicate separation from the normal *Tettigonia* forms, and which allies them to *Euacanthus*.

While ordinarily considered a rather rare species this certainly occurs during a part of the year in its particular haunts in great numbers—that is in the rather rank blue grass of timber areas. In such locations it has been estimated to occur at the rate of 50,000 per acre.

DIEDROCEPHALA MOLLIPES SAY.

Tettigonia mollipes Say. Jour Acad. Nat. Sci., Phila., IV, p. 312, 1831. Comp. writings II, p. 386. *Aulacizes mollipes* Fitch. Homop. N. Y. State Cab., p. 56, 1851. *Diedrocephala mollipes* Walker. Homop. Suppl., p. 253, 1858.

This species has been observed heretofore, and a record of two broods a year indicated. Observations this year show a somewhat later appearance of the spring brood, larvæ occurring through June and first week in July, adults appearing the last week in June, continuing through July, and to about the 20th of August. The second brood of larvæ appeared about the second week in August, running through September and maturing in October and November. First adults of second brood appeared about September 15th and continued through the season. Hibernation seems to occur in all stages, considerable irregularity being shown, but the main body being adapted to the hibernation of eggs.

The range of food plants is large, there seeming to be little choice between annual or perennial grasses. It has been recorded from *Adropogon scoparius* and *provincialis*, *Panicum crus-galli*, *scoparium*; *Setaria viridis* and *glauca*. Wheat, oats, barley (especially volunteer growth), slough grass (*Spartina cynosuroides*), wild rye, (*Elymus canadensis*). It occurs less commonly on blue grass, probably in most cases only when other grasses are present.

As egg deposition in autumn is almost entirely confined to large-stemmed grasses, the destruction of these in pastures is advisable.

DIEDROCEPHALA NOVÆBORACENSIS FITCH.

Aulacizes novæboracensis Fitch. Homop. N. Y. State Cab., p. 56, 1851.

This is a larger and lighter colored species than *mollipes*, and may be further distinguished by the blunter head and the two black spots at the tip. It has been found to occur only in sloughs or in heavy grass adjacent to them, especially slough grass (*Spartina cynosuroides*).

The adults were taken through the last of June and through July, and again from the middle of August through September. It seems to be decidedly limited in its range of food plant, and would be of little economic importance except where slough grass is used for hay.

DIEDROCEPHALA COCCINEA FORST.

Cicada coccinea Forst. Nov. Species Ins., p. 96, 1781.

This is the brightest colored species of the genus occurring at Ames, and is intermediate in size between *mollipes* and *novæboracensis*.

The vertex and scutellum are bright yellow. The pronotum is variously marked with green, red and yellow. The elytra are bluish-green, with two broad purple stripes, and a narrow yellow margin. Below, all yellow, except a narrow black line just under the vertex. Length, nine to ten mm. Readily separated from *versuta* by the absence of dark markings on the vertex, and the larger size.

The larvæ are of a pale yellow color throughout. Head much inflated, convexly pointed, resembling that of adult but larger; thorax broad, abdomen long and slender. The pupæ are still lighter colored, and have a scarlet mark on each wing pad.

This species is two-brooded. The larvæ were taken nearly full grown about the 1st of June. Adults were taken from about the middle of June through July, and again through September and October.

They were taken from woody regions, but usually swept from the undergrowth of grass and weeds. Adults of the second brood were taken from coarse grasses long after the trees had shed their leaves.

XEROPHLOEA VIRIDIS, FABR.

(Pl. xix, Fig. 1.)

This grotesque species occurs throughout the entire United States at least. Van Duzee reports it from New York to Florida,

Texas, Colorado, and California. In addition to this, specimens are at hand from Oregon, Utah, Arizona and Nebraska, and it has been collected at Ames rather commonly.

The adults are six or seven millimeters long by two millimeters wide across the pronotum; the head is slightly narrower than the pronotum; eyes small; vertex flat, produced and roundly angled in front, anterior margin very thin. The elytra are long and angularly pointed behind, the claval area is nearly flat while the corium is strongly deflected, becoming perpendicular at the tip, giving the insect a wedge-shaped appearance. The entire dorsal surface is coarsely pitted. The females are bright green with the tips of elytra lighter, sometimes clouded or minutely dotted with darker along the margins; the males have in addition a broad median smoky line on the vertex and an irregular transverse dark band on the pronotum more or less strongly margined with lighter before.

Genitalia: The last ventral segment of the female is divided medially to its base and consists of two long, roundly pointed lobes; male valve broadly, obtusely rounding, length and breadth about equal; plates narrow, spatulate, two and one-half times the length of the valve.

Larvæ: Similar in form to the adult but with a broader body and longer head; vertex one-half longer than wide, acutely angled before, margin very thin, whole depth of head less than one-fourth the length of the vertex; abdomen short, dorsally carinate; color green, the entire surface covered with short white hairs arising from minute black spots; a pair of larger black spots near the base of the wing pads and another pair on the posterior margin near the inner angle.

Larvæ were found nearly full grown in August; the adults were taken from the second week in August until October. They were swept from a native grass pasture where they were fairly abundant. Specimens from Nebraska and Utah bear dates from May to July, indicating that the species is two-brooded. Observations were not made upon the field where it occurred during the first half of the season, which would account for its not being found sooner.

This species agrees in every particular with Burmeister's description and figure of *grisea* Germar, from Brazil, and undoubtedly it should be placed as a synonym of that species. But Fabricius' description of *viridis* from "Americæ insulis" precedes both, and though brief, agrees well with them and

probably characterizes the same species, at least so far as we know no other species which could answer their description occurs.* If this is correct the synonym will stand.

Xerophloea viridis Fab.

Cercopis viridis, Fab. Ent. Syst. IV 50, 13, 1794.

Xerophloea grisea, Germar Zeits. F. G. Entom. I, 190, 1, 1839.

Xerophloea virescens, Stal. Ofv. Vet. Ak. Forh., 1854, p. 94, 30.

Xerophloea viridis, Fabr., Stal. Hemiptera Fabriciana, II, p. 59.

Parapholis peltata, Uhler Bull. U. S. Geol. and Geog. Surv., III, p. 461, 1877.

Xerophloea peltata, Uhler Stand. Nat. Hist., II, p. 248, 1884.

Professor Uhler, in the Standard Natural History (vol. II, p. 248) gives the range of the species as from Massachusetts to Rio Janeiro in Brazil, thus covering the territory indicated by the three descriptions.

GYPONA GERMAR.

Although the *Gyponas* have never been recorded as grass-feeding species the observations this season show that for one of them at least this is an exclusive habit, and for others apparently a normal one.

The species are widely variable in color and size, and the genus needs a thorough revision in order to reduce to consistent species the long list of so-called species which has arisen from the characterization of these numerous varieties.

Structurally the species are very constant and present definite characters in the shape of the head, the venation and the genitalia.

GYPONA OCTO-LINEATA SAY.

Tettigonia octo-lineata Say Con p. Writ, II, 257.

Gypona striata Burmeister, Gen. Ins. Gen. 16, No. 9.

Gypona flavilineata Fitch, Homop N. Y., State Cab., p. 57.

Gypona quebecensis Provancher, Nat. Canad. IV, 352.

Gypona cana Burm, Gen. Ins., Pl. 16, No. 10.

Gypona flavilineata, Spangberg, Spec. Gyponæ, p. 8.

This is the longest and one of the narrowest species in the genus, on account of its long, narrow elytra, much exceeding the abdomen. It varies in size from large females eleven or twelve mm. long by three mm. wide down to the smallest males only seven or eight mm. long by two mm. wide. The vertex is two-thirds as long on the middle as the width between the eyes, front margin very thin, roundly produced. Ocelli small, slightly behind the middle of the vertex; elytra long and narrowed to a blunt point behind. The venation is indefinite, consisting of fine reticulations on the apical half, and sometimes including the whole surface except the base of the costa.

* A series of thirteen specimens of this insect from Cuba, kindly sent by Mr. Robert Combs, shows most perfect agreement with Iowa specimens, and no other species of the genus is represented in his collecting.

Genitalia: Ultimate ventral segment of the female moderately long, nearly truncate behind, curved downward in the middle, giving it an emarginate appearance, the edge often thin and membranous. The last ventral segment of the male longer than the pronotum, truncate, concealing the valve. Plates narrow, ligulate, nearly four times longer than wide, longer than the last ventral segment, nearly equaling the pygofer, separated at the base by one-half their width, obliquely overlapping at tip. Pygofer broad at base, obliquely truncate from below, tips produced incurved and touching each other.

Color very variable, early specimens of both broods, especially of the first, light green, the yellow lines indistinct; elytra nearly hyaline, nervures weak. This form is the *flavilineata* Fitch, and *striata* Burmeister. Late specimens of the first brood and nearly all of the second are dark green with the elytra strongly reticulate. The yellow lines may be strongly marked or almost wanting; these include the forms described as *quebecensis* Prov., *cana*, Burmeister and *flavilineata* Spangberg. Specimens collected during the latter part of September and throughout October were more or less tinged with red, especially in the females. Specimens being taken which varied from the lines red, through forms that had the lines and the elytral reticulations red, to females that were almost entirely scarlet dorsally, these last being the typical *octolineata* form.

Throughout the whole series the structural characters, with the exception of the strength and number of the reticulations, scarcely varied.

These conclusions are based on the examination of hundreds of specimens showing the most complete intergradations in all these variations. In accord with the general rule for jassids, the first brood, mostly *flavilineata* form, are weakly veined, and those of the second brood, mostly *octolineata* form, are strongly veined and more highly colored.

Larvæ are very broad and depressed, more so than the adult, which it much resembles. The vertex is abruptly narrowed in front of the eyes, then strongly projecting with parallel margins and a broadly rounding apex, the whole projection extremely thin, antennæ nearly as long as body, basal joint as long as vertex, abdomen long and compressed; general color green.

The pupæ are broader, shorter, darker green than the larvæ, and have two fuscous spots on the inner angle of the wing pads.

Larvæ were found June 16th, small to half grown, continuing abundant until the middle of July. Adults appeared about the first of July, continuing till the middle of August. Second brood larvæ occurred into the latter part of August, and on through September. Adults appeared in September and October.

This is by far the most abundant species of the genus, and occurs throughout the entire region east of the Rocky mountains from Canada to Texas, at least, and is closely related to the South American *lineata* of Burmeister, if not identical with it.

In common with other jassids which have a wide distribution, it does not seem to be confined to any particular food plant, but may be found almost everywhere, preferring rank growths in shaded situations. It is the only representative of the reticulated elytral group occurring at Ames, and is unique in that it is two-brooded, while the other species are all apparently only single-brooded.

GYPONA BIPUNCTULATA WOOD.

Gypona bipunctulata, Woodworth, Bull. Ill. State Lab. Nat. Hist., III, p. 30, 1887. (♀)

Gypona nigra, Woodworth, Bull. Ill. State Lab. Nat. Hist., III, p. 31, 1887. (♂)

This is the largest jassid known to occur on grasses in Iowa, and presents a very marked difference between the males and females. The females described as *bipunctulata* by Woodworth are bright green, stout, deep-bodied. The vertex is short, ocelli small, and there are distinct black dots on the pronotum, one each side about half way from the middle to the margin; also a distinct dot on the base of each elytron just under the outer angle of the pronotum.

The male, which was described as *Gypona nigra* by Woodworth, has the head and pronotum black, margined with light green. The black color nearly conceals the dots of female pronotum. The elytra are hyaline and allow the black tergum to show through, so in most specimens there is usually a quite uniform dark color to the whole upper surface except the margin. The genital plates are broad, shorter than sixth segment, truncate at apex.

Woodworth described this species from Illinois, and we have specimens from Kansas aside from numerous examples taken in Iowa.

The adults appear the middle of July, the males about a week before the females, and continue to the latter part of September. They have been taken only from grasses.

Full-grown larvæ were swept from prairie grass July 6th. They are shorter, stouter, with shorter vertex, covered all over with stiff white hairs.

In addition to these a small larva was taken from the base of an *Elymus* stock, September 5th, and another larger one May 22d. This pupated in cage May 29th and died June 16th. These two larvæ are doubtfully referred to this species which, if correct, would indicate *Elymus* as the larval food plant.

EUACANTHUS ACUMINATUS FAB.

(Pl. xix, Fig. 3.)

Cicada acuminata, Fab. Syst. Ent. IV, 33, 40, 1794.

Euacanthus orbitalis, Fitch. Homop. N. Y. State Cab., p. 57.

Fitch's description of *orbitalis* and the specimens at hand agree in every respect with the description of *acuminatus* and with European examples of the species, so that there seems to be no question as to their specific identity.

This species occurs throughout the whole of central Europe, and probably has an equally general distribution in this country. It has already been reported from Canada, New York and Michigan, and specimens are at hand from Washington, D. C., and Vancouver's Island, besides adults and larvæ taken at Ames this season.

The adult is very stout-bodied with a broad vertex and small round eyes. Length, 6 mm., width on center of costa, 2mm.

Vertex about equaling pronotum in length; nearly twice broader than long, obtusely angled anteriorly, medially and laterally carinate; ocelli on the vertex near the carinate anterior margin, about equally distant from eye and tip; front broad above, rounding to the small clypeus; base of the antennæ overhung; pronotum short; elytral venation simple, first sector only once forked; color, shining black with margin of eyes, tip of vertex, elytral nervures and a large spot near the base of the costa, white.

Genitalia: Ultimate ventral segment of the female long, rounding, posterior margin arcuated and slightly notched. Male valve obtuse, short; plate long and very narrow, exceeding the pygofer.

Larvæ white: Head similar in form to the adult, much more inflated and produced, one-third the length and nearly half the size of the whole insect, four times the length of the bead-like eyes, evenly and finely covered with short white hairs; antennæ extending beyond the middle of the abdomen; thorax narrower

than the prominent eyes; abdomen slender, dorsally carinate, tipped with coarse white spines; entire body covered with fine white pubescence; thorax and abdomen sparsely set with curved black hairs pointing backward. Length of full-grown larvæ 5.50 mm.

Larvæ and adults were taken the first week in July; adults continuing to be found throughout the month. Swept from a woody pasture in which numerous *compositæ* abounded. Larvæ in cages fed indiscriminately on a variety of plants taken from similar situations.

Although not hitherto recorded specimens of the other European species, *Euacanthus interruptus* L., have been represented in American collections but have been placed with Fitch's *orbitalis*. Those at hand are from South Carolina, but it doubtless has much the same distribution as *acuminatus* here, as it does in Europe.

The position of the ocelli in this genus is strongly suggestive of the *Acocephalinae*, while in some other respects it appears to be more closely related to the *Tettigoninae*. This and the following genus, which seem very closely allied, may very probably represent generalized or intermediate forms connecting the two sub-families.

NEOCOELIDIA TUMIDIFRONS G. & B.

Hemiptera of Colorado, p. 104.

The male of this species was described in "Hemiptera of Colorado," page 104. The female taken at Ames this season differs considerably from the male description, and may be characterized as follows:

FEMALE.—General aspect of *Euacanthus*; light yellowish-green above, no dark markings visible on the scutellum. Below, yellowish-green with rostrum, oviduct and spines on legs orange. Vertex furrowed and nearly parallel margined next the eye as in *Euacanthus*, but lacking the carinæ, then convexly conically rounding to the front; length on middle twice that next the eyes, width between eyes equaling length. Ocelli small, on the rounding margin of vertex as in *Xestocephalus*, about one-third the distance from the eye to tip. Front at ocelli one-half wider than at loræ. Antennæ inserted beneath a ledge, nearly as long as body; first and second joints large; pronotum very short on the middle, continuing broadly behind the eye and around back of the genæ as in *Euacanthus*. Elytra about equaling the abdomen; spines on the hind tibiæ very strong,

a crown of short spines on the tip of the tibia, and the first two tarsal segments.

Genitalia.—Ultimate ventral segment of female nearly as long as width at base, elevated in the middle; posterior margin truncate, with a broad median notch; pygofer narrow, moderately exceeded by the oviduct; the margins and tip studded with short, stout, orange spines; length, 4.50 mm.; width on center of costa, nearly 2 mm.

Larvæ.—Half-grown specimens taken the middle of September already possessed the characteristic head and pronotum of the adult. The antennæ were longer than the body, basal joints very large, and arising from under a well marked ledge; color, bright green, with six black spots, as follows: A pair of round ones occupying the anterior half of the eyes, a pair on base, and another on posterior margin of the wing pads, directly behind and in line with the eyes, anterior pair partly concealed by the pronotum. Spines on the genitalia, and legs stronger than in the adult.

This species was taken in upland pastures in which *Andropogon scoparius*, *Bouteloa hirsuta* and *curtipendula* predominated. Adults were taken the latter half of August; half-grown larvæ were found September 13th and 17th.

This is a very peculiar species, and suggests a relationship between *Euacanthus* and *Xestocephalus*, two of the lower genera, placed respectively in the sub-families *Jassince* and *Tettigonine*.

XESTOCEPHALUS PULICARIUS VAN D.

Bull. Buffalo Soc. Nat., Sci. vol. IV, 1894.

This is a narrow, convexly conical headed little species with broad maculate elytra and a brown vertex marked much as in *Tettigonia hieroglyphica*. Length about 3 mm.

This species might easily be mistaken for a *Deltocephalus* but for the ocelli which are situated nearly half way from the eyes to tip of vertex. It was found rather commonly on blue grass in shaded locations through July and August.

Very generally distributed north, and specimens have been received from Mississippi (Weed).

XESTOCEPHALUS CORONATUS N. SP.

(Pl. xix, Fig. 2.)

Form and size of *pulicarius* nearly, but with head and pronotum shining black, with white markings; length, female, 3 mm.; male, hardly 2.50 mm.

FEMALE. Head nearly equaling pronotum in width; vertex two-thirds the length of the pronotum, one-half longer on middle than next eye; width at base nearly twice the length, convexly rounding to the front; lateral and posterior margins, a median stripe extending forward across the disk, and ocelli white; tip white, broadly margined with orange. A broad lateral margin approaching so near the ocelli as almost to complete the white margin and reduce the black to a large spot on either side of the median line of the disk. Front narrow at ocelli, widening to antennal pits, then rapidly narrowing to the clypeus; light orange above, shading to black below; clypeus and loræ black; genæ broad, white; antennæ long, arising from under a distinct ledge; pronotum short, margins nearly parallel, black, with a transverse white band just before the posterior margin; scutellum, basal half black, with a narrow median stripe, apical half orange. Elytra maculate with black as follows: The middle and tip of clavus, apex of elytra, a small spot on the costa before the apex, a broad, slightly oblique band arising beyond the middle of the costa and extending to the clavus, branching before the middle and running narrowly to the anal cell and a smaller curved band near the base of the costa, sometimes uniting with a median one near the claval suture.

MALE. Vertex without the median stripe or orange marking; upper part of front and all the vertex within the white margin, shining black, except ocelli and a point on the tip equaling them in size, white; lower part of front and clypeus orange.

GENITALIA. Ultimate ventral segment of female very broad, posterior margin straight, roundly notched in the center, slightly deeper than in *pulicarius*. Male valve short, obtusely concavely pointed; plates inflated, broad at base, concave, narrowing to an acute apex; apex curved upwards around the pygofer which, together with the plates, are margined with plumose white hairs.

Two males and one female of this very distinct little species were taken from a deeply shaded patch of bluegrass in August. Ames, Iowa.

THE SHOVEL-NOSED LEAF-HOPPER.

DORYCEPHALUS PLATYRHYNCHUS, OSB.

(Pl. xx, Fig. 1.)

Canadian Entomologist, XXVI, p. 216, 1894.

This very peculiar insect has hitherto been recorded only from Ames, Iowa, and West Point, Neb., and has been considered very rare, only three or four specimens in all having been seen prior to the present season. Nothing was known as to its life-history or food habit. During the present season, however, it has been found in large numbers, and since it has bred freely in the breeding cage, it has been possible to determine its full life-history.

At first sight one would infer that it would be a very conspicuous object, an easy victim for natural enemies or the

obtrusive collector. As a matter of fact this proves to be only a remarkable adaptation to its food plant (*Elymus*) in color, form and life-history.

The linear aspect and dark dorsal stripe, more or less broken or obscured, harmonize so well with the ordinary rusty *Elymus* stem to which it closely adheres and from which it can scarcely be driven, either in larval or adult stage, that it is detected with great difficulty. They rely on this mimicry for protection rather than upon flight or leaping. So perfect is this protection that one may look for some time at a few stems of grass where dozens of the insects are known to occur and fail to locate them.

The figure shows the distinctive features sufficiently and a full description is unnecessary here, but it may be proper to call attention to the fact that there are two forms of females, one having the elytra very short (wings proper rudimentary), as figured, the other with much longer wings and smaller body and more pointed rostrum, more closely resembling male. This flies readily while the other is entirely incapable of flight and never leaves the plant on which it is hatched. The males are all long-winged.

It is single brooded, the adults appearing about the middle of May and continuing in decreasing numbers until the end of July. During the last week in May and the first week in June the eggs are deposited; the female selects a spot about two inches above the base of the first or second leaf from the bottom; having selected the spot apparently with much care, she takes her position head upwards, legs placed close together and tarsi clasping the stem; then, raising the body the length of her legs and curving the abdomen upward, she unsheathes the ovipositor from the pygofer and brings its tip down against the grass stalk, pointing backward slightly from the perpendicular; she then moves slowly around the stem keeping the body parallel with it and the guides pressed firmly against it until they catch under the edge of the encircling leaf sheath; having done this they are gradually forced under the sheath, usually extending almost half way round the stem. As they are gradually forced in the abdomen straightens and then hollows until, when the ovipositor is fully inserted, the abdomen is curved down and the pygofer is pointed upward and backward at more than a right angle with the guides. Having reached this position she works slowly backwards, opening the

sheath downward with a peculiar sawing motion alternating with a slight pause for the deposition of an egg.

The eggs are one and one-half millimeters by one-third millimeter, cylindrical, gradually tapering from a point near the head back to an obtusely rounded tip; the anterior end is cut off obliquely from one side and rounded from the other, coming to an obtuse point. They are deposited in a continuous row, from thirty to fifty, side by side, curving slightly around the stem with their heads toward the edge of the sheath, from which they are distant about one-third the circumference. The time occupied in actual deposition is from twenty to forty minutes, but the selection of a location and the catching of the sheath edge often occupies several hours.

Although the eggs were deposited through a period of two weeks or more they apparently all hatched at about the same time; the time evidently depending considerably upon favorable conditions of temperature and moisture, for, up to July 2d, no larvæ had been observed either in the cages or in the field. On this afternoon the air was very oppressive, and remained so until cleared by a heavy thunder storm during the following night. On the morning of the 3rd they were observed just emerging from the eggs in the cage, and examinations showed that they had hatched in the field also. The earliest deposition from which they were observed to issue on this date was made May 28th, and the latest on June 9th, while the majority were deposited June 4th and 5th. This gives from twenty-six to thirty-eight days, with an average of about one month, as the period of incubation.

The freshly hatched larvæ have shorter and blunter heads than the adults, and are much more active, but within a week or two the head has elongated, and it has adopted the sluggish habit of the adult.

Upon hatching, the larvæ immediately arrange themselves along the base and margins of the broad leaves parallel to the veins, where they remain stationary for weeks at a time, so closely resembling the rust spots and discolorations occasioned by their punctures that the chance of their detection is slight, or, they ascend to the head, where they conceal themselves so effectually among the glumes and sheaths upon which they feed, that one might carefully examine a head and pronounce it free from them, only to find, on shaking it violently, that it contained a whole colony. Here they stay until the head ripens

in September, when they descend to feed on the second growth and the surrounding grasses until winter, when they crawl into the thick clump of the *Elymus* and hibernate, appearing again in early May and changing to pupæ. From then on until the middle of the month they feed on any green plant, near enough to be reached, crawling at last to the top of some blade of grass and issuing as adults over ten months from the time of hatching from eggs.

This species in common with the others which occur in long and short-winged forms, are usually very thick, where they occur at all; but, the eggs being deposited only upon the *Elymus*, they are limited in their range to a radius of a few feet at most from their host.

They have been observed to feed upon the heads of *E. virginicus* indiscriminately with those of *canadensis* where the two grasses are near together, or near enough for migration, and in the spring, when the larvæ were large and abundant and the grasses small and inconspicuous, they were found upon everything occurring within a reasonable distance of the host.

In view of the fact that wild rye is one of the most deleterious of our grasses, and has been the cause of considerable loss to our stockmen in the past through its propensity to ergotism its eradication from pastures and meadows would of itself be beneficial, and at the same time avoid any possibility of further injury from this species of jassid. Another method which would accomplish both ends sought and still enable us to make use of its valuable food properties would be to closely mow the *Elymus* clumps the latter part of each June. This would cut off the head-forming stems before they had developed ergot, and would destroy the eggs of the shovel-nose, and at the same time leave the grass in good condition for immediate pasture, or, if not pastured, produce a better crop of hay than without the mowing.

THE SPOON-BILL LEAF-HOPPER.

HECALUS LINEATUS UHL.

(Pl. xx, Fig. 2.)

Glassocratus lineatus Uhler. Bull. U. S. Geol. and Geog. Surv. III, p. 464, 1877. (♀)

Glassocratus fenestratus Uhler. Bull. U. S. Geol. and Geog. Surv. III, p. 464, 1877. (♂)

This rare species is intermediate in form between the *Dorycephalus* and *Parabolocratus*. The female measures 12 mm. to the tip of the exerted, attenuate ovipositor. The head is 2.50 mm.

long by 2 mm. broad, slightly narrowed in front of the eyes, widening immediately to a spoon-shaped tip, which is thin and slightly reflexed. The body color is bright green with four equidistant parallel lines extending over head, thorax and scutellum; the nerves of the elytra and the ovipositor orange red.

The males are quite different from the females in appearance, and were described by Professor Uhler as *Glossocratus fenestratus*, and have hitherto been regarded as a distinct species. They are much smaller, measuring scarcely 8 mm. to the tip of the style-like pygofer.

The head, thorax and basal part of the elytra are marked like the female, but the ground color approaches orange. The apical half of the elytra and the abdomen are quite different. There is a narrow black band just back of the middle of the elytra and a broader terminal one, between these is a hyaline area with a small curved dark spur extending in on the center of the outer margin. The abdomen is annulated with black, and the terminal segment, valve and attenuate plates black.

The larvæ are narrow, elongate, closely resembling the female in color and in the stripes which extend along the abdomen also.

The species has been reported from Kansas and New Jersey, including only a few specimens in all. There was a specimen in the VanDuzee collection from New York, and one specimen had been taken at Ames and another at Batavia, Iowa.

The larvæ were found on an isolated patch of slough grass (*Spartina cynosuroides*) early in August. They were then nearly full grown.

The adults were taken *in coitu* in the middle of August, and from then on through September were found in some numbers on the limited patch where their food plant occurred.

It is highly probable that the eggs were deposited in the stems of the slough grass before the middle of September, in which case the ordinary time of mowing would be an effectual remedy, and would account for the rarity of the species in cultivated areas, or in sections annually overrun by prairie fires.

PARABOLOCRATUS VIRIDIS UHL.

(Pl. xxi, Fig. 1.)

Glossocratus viridis, Uhler, Bull. U. S. Geol. and Geog. Surv., III, p. 462, 1877.

Paraboloeratus viridis, Uhler, Stand. Nat. Hist. II, p. 247, 1884.

Occurring only on the wild oat (*Stipa spartea*) this species furnishes another example of a jassid confined strictly to one species of grass as a host and one to which it is remarkably adapted in coloration and life-history.

The adult female is about 7.50 mm. long by 2 mm. broad, with a parabolically curved, thin edged vertex and a stout abdomen, attenuating posteriorly and extending beyond the rounding elytra. The males are smaller and have the vertex shorter and more obtusely pointed. The abdomen is smaller and does not extend beyond the narrow and nearly parallel margined elytra.

They are both of a uniformly deep green color above, somewhat lighter below, with a narrow band under the sharp vertex, and the eyes dark; the exserted tip of the ovipositor, orange red.

The first brood of the adults appeared the first week in May and remained until the middle of June, disappearing gradually. They feed principally upon the leaves usually about the middle, feeding on either side and either end up, with equal ease.

The eggs are deposited during the last of May and the first week in June. The females usually selecting a position just above the first leaf base and invariably placing themselves head downward, exert the ovipositor and insert it under the flap of the sheath, gradually working backwards up the stalk for a distance of two inches or more and depositing from seventy to one hundred and twenty eggs within an hour.

The eggs are 1.25 mm. long by .25 mm. broad, cylindrical, of nearly uniform size and obtusely pointed at both ends, arranged in a single series, side by side, curving considerably around the small stem.

The larvæ appeared the last week in June, giving an incubation period of fifteen to twenty days. Upon bursting the egg case the larvæ crawl part way out from under the sheath and remain quiescent in this position for an hour or two when, becoming suddenly active, a flock of very small larvæ may be seen ascending the stalk and distributing themselves upon the leaves, while a row of freshly shed skins with the abdomens still remaining under the sheath, their tips scarcely free from the egg shells, explains the cause of the delay.

When first hatched the larvæ have a characteristic head, depressed, light colored, soon deepening, however, and in some assumes more or less definite stripes of darker which, in the most extreme forms coalesce, and a black specimen is the result. In normally colored specimens there is on either side of a median light line a narrow black stripe originating in a spot on the anterior margin of the vertex, obscured across the disk and

becoming marked again upon the posterior margin, enlarged and lobate on the thorax, then narrow with definite parallel margins to the last segment of the abdomen, where they expand and meet at the tip. Besides these there is a broad stripe extending from the inner angle of the eye back across the thorax, where it is margined internally with light to the abdomen, where it margins all but the last segment.

They require about a month to develop, maturing during the latter part of July and the first of August, the adults remaining until the middle of September.

The eggs for the second brood are deposited from the middle to the last of August and the larvæ appear in September, becoming full-grown before winter, when they hibernate, appearing to pupate about the first of May and becoming adults before the middle of this month.

Stipa is another troublesome grass, but too widely and evenly distributed over the prairies to eradicate easily. It may, however, be mowed closely between the 10th and 16th of June to destroy the first brood of eggs and the troublesome barbs of the grass at the same time, leaving an undergrowth of nutritious grass free from jassids. Then, should the adults appear in considerable numbers in August, a second mowing during the latter part would effectually dispose of the second brood of eggs.

Stipa is a very valuable grass to the stockmen of the prairie regions, where blue grass has not been introduced, as it appears two or three weeks earlier than the other wild upland grasses, thus furnishing much earlier grazing than could otherwise be obtained.

PLATYMETOPIUS, BURM.

The American representatives of this genus agree with the European *P. vittatus*, Fab., in form and the generic characters may be stated for our species as follows:

Head distinctly narrower than the pronotum; vertex narrow, produced and very acutely angled, making an acute angle with the face. Face long, narrow, front long, broadest at the ocelli, narrowing above to the tip of the vertex, below to the antennal pit, from them to near its apex nearly parallel margined, narrowing slightly to the clypeus; clypeus strongly constricted before the middle, widening to the broad apex; loræ subovate; pronotum short, strongly produced beneath the eyes, lateral margin long. Elytra with more or less of fine irrorations in the areoles and small hyaline white points near the ends of the

cells; two cross nervures and a series of cross veinlets along the hyaline costa always present.

The genitalia seem to be very constant and very similar in the different species and are consequently of little value as specific characters. The last ventral segment in the female is long, obtusely angled or rounding posteriorly. The last segment in the male is angularly excavated; valve large, roundly pointed. The plates are broad and also convexly pointed, similar in shape to the valve and about twice its length.

The three species occurring at Ames agree in being two-brooded, the broods occurring at about the same time, the adults appearing in June and again in August, remaining less than two months each time. The larvæ, of the three species at least, agree in being broadest at the middle, pointed at both ends, light, with dark margins extending in front of the eyes and meeting under the vertex.

PLATYMETOPIUS ACUTUS SAY.

Jassus acutus, Say, Jour. Acad. Nat. Sci. Phila., VI, p. 336, 1831; Compl. Writings, II, p. 382, 1869.

Platymetopius acutus, Uhler, Bull. U. S. Geol. and Geog. Surv., III, p. 473, 1877.

This widely distributed form may be recognized by its remarkably, acutely, pointed vertex and narrow elongate face, together with a row of black marked cross nervures along the costal border and the finely irrorate elytra. Length, 5 mm.

The larvæ resemble the adults in having the head elongate, narrower than the pronotum. When full-grown they are about four and one-half millimeters long by two millimeters broad in the middle where they are the widest, and from which they gradually and about equally, narrow to an acute point at either end.

Color: There is a broad dorsal light stripe including all the vertex, parallel margined across the thorax where it is slightly wider than between the eyes, constricted on the base of the abdomen and again before the tip expanding on the disk of the abdomen, and again on the extreme tip. This stripe is distinctly red on the center, shading out to creamy white on the margin. The constrictions on the abdomen sometimes completely dividing it into two spots, one on the disk and another on the tip. A marginal black stripe extending the entire length of the body on either side, meeting entirely below the edge of the vertex in front, including numerous fine white maculations. Below, inside the marginal stripe, creamy white.

The larvæ appear the latter part of May, maturing before the end of June, adults appearing before the middle of June and continuing till the middle of July, larvæ again appearing in July, maturing in August, adults from the middle of August on into October. The larvæ were taken in grass lands but were more abundant in shady situations.

PLATYMETOPIUS FRONTALIS VAN D.

Canadian Entomologist, XXII, p. 112, 1890.

This species may be readily recognized by its much darker appearance, being dark brown to black with a broad lemon-yellow face and the small round white spots in the ends of the elytral areoles distinct. It is slightly shorter and stouter than *acutus* and has a shorter vertex.

The larvæ bear a strong superficial resemblance to those of *Deltocephalus inimicus*, but may be readily separated by the presence of the marginal stripe in front of the eyes.

Form and pattern of ornamentation similar to that of *P. acutus* but much shorter and stouter. Vertex very much shorter.

Color: A dorsal light yellow to cream-colored stripe narrowing to a point on the tip of the vertex, broadening with irregular margins on the disk of the abdomen, interrupted before the tip by a narrow black band on base of last segment. Marginal dark stripe extending equally above and below the border of the vertex meeting in a point at the apex, a small lobate expansion of the dorsal stripe midway between edge and tip of vertex just behind the white frontal suture. Below, white, tip of posterior femur and second tarsal joint annulated with black.

Life-history similar to that of *acutus*; larvæ from the last of May nearly through June; adults from the middle of June nearly through July; larvæ from the middle of July nearly through August; adults from the middle of August through September.

Found exclusively in shaded situations; larvæ were swept from undergrowths of grass and weeds.

This species has a quite extended distribution, being credited by VanDuzee to Canada, New York, Illinois, Iowa and Kansas, and as it does not occur in such abundance as some of the other species, and would, therefore, be less likely to appear in collections, it may be assumed to occur throughout the northern United States east of the plains at least.

PLATYMETOPIUS CINEREUS, N. SP.

(Pl. xxvi, Fig. 1.)

Form of *P. acutus* but smaller and lighter colored, equaling *fuscifrons* in size. Length, female nearly 4 mm., male, 3.50 mm.

Female: Vertex nearly twice as long as broad, slightly more than twice as long on the middle as next the eye; light yellowish with fine brownish irrorations; a median light line, broadest on tip fading out on the disk, on either side of this a curved line extending back from the edge on to the disk. Front with the usual dark V under the vertex, remainder of the vertex and the clypeus light lemon-yellow; loræ and genæ slightly, finely maculate with brown; pronotum short, fulvous brownish, lateral margins long, posterior angles obscure, emarginate; between them traces of longitudinal light lines; scutellum large, light yellow, tip darker. Elytra light with fulvous brown irrorations; apical and costal veinlets dark, terminal spots in cells and costal margin whitish-hyaline; tip slightly clouded with dark fuscous.

Male: Smaller and shorter, the vertex is only about one and one-half times as long as broad and the terminal cells are clouded with fuscous.

Genitalia: Ultimate segment of the female long, rounding behind narrowly notched in the middle, slightly lobately produced either side of the notch; pygofers light yellow, three times as long as width at base. Male valve large, roundly pointed, dark at the base; plates roundly pointed, twice the length of the valve, maculate.

Larvæ: Similar in form to those of *acutus* but smaller; they are about three and one-half millimeters long by one and one-half wide in the middle when full-grown. Widest just before the middle, gradually and regularly narrowing to an acute point at either end. There is a broad lemon-yellow dorsal stripe, narrow, wedge-shaped on the vertex with indefinite margin; broad, with definite parallel margins on the thorax, constricted slightly on the base and again before the extremity of the abdomen, bordered on either side by a dark fuscous marginal stripe, irregular in width, narrow before the eyes, meeting under the vertex. Numerous fine white maculations of various sizes dot this stripe.

The larvæ are readily distinguished from those of *acutus* by the absence of red in the dorsal stripe, and from those of *frontalis* by the much more elongate form.

The larvæ were first observed early in June, when they were nearly full grown, and by the third week had disappeared. The adults appeared very thickly by the middle of June and continued in decreasing numbers until after the middle of July. The second brood of larvæ appeared by the last of July and continued in large numbers up to the middle of August. The second brood of adults appeared the second week in August, continuing through September.

This is the smallest known species of the genus, and the most abundant at Ames, occurring everywhere that wild grasses are found. Specimens have also been received from Kansas, Nebraska and Arizona, showing it to have a wide distribution throughout the prairie and plain region at least.

By a process of elimination of grasses not occurring in places where the larvæ were found abundantly its list of host plants

may be reduced with a reasonable degree of certainty to three: *A. scoparius*, *B. hirsuta* and *curtipendula*, and from its scarcity in a field of nearly pure *scoparius* its probable host is a *Bouteloa*. This agrees well with its known habitat, which corresponds with that of these grasses.

REVIEW OF THE GENUS DELTOCEPHALUS.

This genus is distinctively a group of grass-feeding species, probably the most important in this relation on account of its wide distribution and large number of species occurring annually in immense numbers.

The genus was originally founded by Burmeister, who characterized it as follows: Vertex acutely triangular, distinctly margined; width between eyes scarcely equaling length; front broad, convex; vertex flat. Fieber in his synopsis of the *Deltocephali* adds the presence of two cross nervures between the forks of the first sector and the second, as a sub-family character. Later writers have omitted the head characters and depended upon the cross nervure alone for group separation. Mr. VanDuzee, to whose careful and accurate work we owe the greater part of our present knowledge of the American Jassidæ, seems to have accepted and used this character against his own better knowledge and judgment, for, in *Entomologica Americana* (vol. V., p. 93) he says: "This apparently trivial and not infrequently variable character seems almost inadequate for use in separating these two genera, but, correlated as it is with other structural peculiarities, of which it is the most pronounced, it appears to answer well the purpose of its employment, and is much used by Fieber and other European entomologists in synoptical arrangements of the genera." A few years later he described *Athysanus instabilis*, *extrusus* and *servittatus*, placing them correctly in that genus despite the fact that most of the types exhibited the two nervures, thus showing that he appreciated the true generic character. The next year, however, he again yielded to the demands of this variable character and redescribed *D. nigrifrons* as *Thamnotettix perpunctata*, although evidently appreciating their specific affinity, as seen by the following extract: "This insect, though quite distinct generically from *D. nigrifrons*, is difficult to distinguish in specific characters; the markings are almost identical, and the form of the facial and genital pieces differ but little." Dr. Melichar, in his recent work on The Homoptera of Middle

Europe, uses this single character in his synoptical arrangements as a primary basis of division for separating groups of genera, but evidently does not accept it in his distribution of species, as he places species that possess the two cross nervures in connection with a similar forking of the first sector to that laid down for the deltocephali in both *Thamnotettix* and *Athysanus*; while on the other hand he includes under *Deltocephalus* species in which the second cross nervure is wanting.

If the only result of these discrepancies was the misplacement of a few species with respect to their apparent natural affinities it would not be worth while, in consideration of the chaotic condition of other jassid genera, to attempt to restrict one genus at the expense of still more overburdening others. But upon an investigation of the actual conditions existing it has been found that species variable in this respect exist in large numbers, and that they have been and are being described over and over again under different appellations, according as their variable venation places them generically, now appearing as a *Thamnotettix*, now as an *Athysanus*, or even as *Eutettix*, and seldom failing to get at least one representative in *Deltocephalus*.

The variable species may be roughly divided into three classes: First, those species which vary between the opposite sides of the same individual, or between two individuals otherwise exactly alike. *Athysanus extrusus* and *sextivittatus* and *D. concentricus* are good representatives of this class. Second, species which have two distinct forms, both long winged, one form greenish in color and strongly resembling *Thamnotettix*, with only one cross nervure, the other form darker, with subhyaline elytra, possessing two cross nervures, and the other accompanying changes, notably the constriction of the central anteapical cell. *D. nigrifrons*, with its list of synonyms, well illustrates this group. Third, a group in which there are two forms with radically different elytra; one in which the wings are abortive and the elytra only cover the second segment of the abdomen; the venation simple, often rudimentary. In this form the female abdomen is usually very long, ending in an attenuate ovipositor; the male abdomen short, with much enlarged genitalia. The other form, with well developed wings and elytra; the venation variable, but usually strongly Deltocephaloid; both male and female abdomens normal. The forms described as *D. argenteolus* and *minutus*, and as *Athysanus gammaroides* all possess these two forms.

The examination of several hundred examples embracing some twenty species at present referred to five different genera and including all of the above mentioned variations compel the rejection of the cross nervure as an absolute character, or one capable of even specific recognition, except as correlated with other characters, and the re-establishment of the Burmeisteran genus based on head characters. It may be noted, however, that when thus restricted, it contains no species lacking the cross nervure nor any in which it is found to be variable.

The material upon which the revision has been based, and which has been accumulating during a number of years past, consists mainly of the following: Types of the ten VanDuzee species; types or typical specimens of all but two of the Gillette and Baker species, together with a series of several hundred Colorado specimens, received through the kindness of Professor Gillette. Twenty European species of the genus as defined by Melichar, more than half of them direct from him, which, in connection with his recent synopsis, furnish a good basis for comparison of the American and European faunæ. The Van Duzee material in the genus outside of the types, which, together with them, includes all but one of the eighteen described species which he listed in his catalogue. And, lastly, the college collections of thousands of specimens of adults and larvæ, together with a large series of balsam mounts of larvæ, elytra and wings, structural details and dissected genitalia for microscopic examination. These, embracing twenty-five species, among them the one lacking from the VanDuzee material, and thus complete the series of described American species.

After restricting the genus it was found that it could be separated into three well defined groups, each of which has its parallel in the European fauna. In fact, two out of the three groups possess species common to both continents. The first, or reflexed veined group includes species with short pronotum and sharp margined head; the elytra have little or no appendix and the costal veinlets are white-marked, strongly reflexed in one series and nearly right-angled in another. Of this group *bilineatus* represents one extreme and is closely related to the European *formosus*, while *ocellaris* common to both continents, and *sayi* closely related to the European *flori* and *socialis*, represents the other. They agree in being of a general light brown color with definite markings, and are two-brooded as far as known. The larvæ are light, with four brown stripes. The

species of the second group have longer pronotum, longer, narrower elytra, with an appendix, never possessing reflexed veins. Here is placed *debilis*, which is closely related to the European *abdominalis* and *melscheimeri*, which is intermediate between the European *notatus* and *striatus*. The group is nearly unicolorous, without distinct markings; the larvæ are unicolorous, usually yellowish in color. The third group, of which *inimicus* is the best known, have shorter, rounding, more centrally produced heads, with a row of points on the anterior margin of the vertex, extending down to the antennæ on either side. The central ante-apical cell is constricted in the middle and divided by a short nervure. They are closely related to the European *pulicarius*, and, like that species, not typical Deltoccephalids. They are of a general dark color, more or less maculate. The known larvæ are dark margined or banded.

It has been thought best to place this group here for the present, though in a revision of the family it may prove necessary to establish another genus which shall include also such forms as *nigrifrons*.

SYNOPSIS OF AMERICAN SPECIES.

- A. Vertex strong, disk flat or concave, margin in front of eyes straight. Ocelli on a level with the disk of vertex before the upper margin of eye.
 - B. Pronotum short, more than twice broader than long, nearly truncate behind, posterior angles obtusely rounding, side margins long, elytra without a distinct appendix—light colored species with brown markings, larvæ light, with four brown stripes.
 - c. Elytra moderately long, with two outer apical veinlets strongly reflexed to the costa, the next one meeting the costa at nearly right angles, all three white, dark margined.
 - d. Pronotum four-lined, lines sometimes coalescing, black.
 - e. Vertex longitudinally lined or else spotted, ground color, yellow; front, narrow.....*bilineatus*.
 - ee. Vertex transversely lined before the eyes, general color white, front broad, inflated.....*albidus*.
 - dd. Pronotum cinereous, never distinctly dark-lined.
 - e. Third apical cell larger than anal one, face dark above, light below; species four mm or more long.
 - f. Face light or fuscous above, shading out below, no sharp line of demarkation, claval veins not uniting, vertex short, nearly right angled, male genitalia inflated, plates roundly pointed; species nearly unicolorous above, except a broad spot in third apical cell.....*inflatus*.
 - ff. Face black above, white below, line of demarkation sharp, vertex, long, acutely pointed, dark markings above, sharp, veins on clavus coalescing through the middle third, male plates long, acutely, slightly concavely pointed.....*reflexus*.
 - ee. Third apical cell smaller, or only equaling anal one, face usually entirely dark; species less than four mm. long.

- f. Length three and one-half mm. or over, ventral segment of female, with four black, comb-like teeth, male plates broad, almost truncate; species brownish fuscous above..
..... *pectinatus*.
- ff. Length, three mm. or less, ventral segment of female with a broad median projection slightly notched in the middle, arcuated either side, male plates roundly pointed; species light cinereus above.... *abbreviatus*.
- cc. Elytra shorter, broadly obtusely rounded, with the two outer apical veinlets short, at nearly right angles to the costa, third veinlet running distinctly to the posterior margin; species stout bodied, with chocolate brown markings.
 - d. Vertex slightly longer than broad; species not over three and one-half mm. in length, short and stout, with a distinct marking.
 - e. Dark chocolate brown above, nearly black below, a distinct inverted T on apex of front, claval sutures reticulate, central anteapical, cell divided; male valve large, inflated *ocellaris*.
 - ee. Light brown above and below, no reticulations on clavus, central anteapical cell entire, male valve normal, not larger than ultimate segment *sayi*.
- dd. Vertex very broad, breadth and length about equal; species over four and one-half mm. long, markings brownish fuscous or wanting, male plates broad, short, obliquely truncate *configuratus*.
- BB. Pronotum longer, hardly twice broader than long, posterior angles strong, sides short, postero-lateral margin nearly parallel with scutellar margin of elytra, elytra long with appendix, costal veinlets never reflexed, only the first one, ever even right angled; species unicolorous, yellows or fuscous, larvæ unicolorous.
 - c. Elytra only slightly overlapping at tip. Central ateapical cell neither markedly constricted nor extending posteriorly much beyond the adjacent cells, equaling or shorter than outer discoid cell.
 - d. Elytra distinctly green. Vertex lighter, not distinctly lined, tergum and venter and sometimes all of lower side of face varying to black.
 - e. Form stout; length four mm. or over..... *debilis*.
 - ee. Form more slender; species three mm. or less in length..... *minimus*.
 - dd. Elytra not distinctly green, hyaline yellowish, or with the nervures fuscous margined; vertex unicolorous or lined, not spotted.
 - e. Male valve enlarged, inflated, rounding posteriorly concealing all but the tips of the small plates; female segment slightly angularly excavated..... *melschermi*.
 - ee. Male valve normal, less than half the length of the plates, last segment in female produced more or less notched.
 - f. Species distinctly yellow, male plates not longer than broad..... *oculatus*.
 - ff. Species fuscous or greenish, with fuscous markings, male plates distinctly longer than broad.
 - g. Vertex acutely angled; species green, with slight fuscous markings; male valve pointed, female segment with truncate process..... *sylvestris*.

- gg. Vertex little more than right angled; species, brownish fuscous, with light nervures, male valve large, obtusely rounding, female segment deeply notched *cinereus*.
- cc. Elytra broadly overlapping at the tip, central anteapical cell elongate, constricted, distinctly longer posteriorly than the cells on either side, longer than the other discoid cell.
 - d. Vertex orange yellow, general color yellowish, styles distinctly exceeding the long plates... *auratus*.
 - dd. Vertex light fuscous with brownish maculations general color fuscous, styles not visible beyond the short, broadly truncate plates *signatifrons*.
- AA. Vertex short, disk convex, margin in front of the eyes arcuated, tip bluntly produced; ocelli below the disk of the vertex in front of the middle of the eye.
- BBB. Pronotum long, distinctly angled behind, side margins long; species dark maculate or black; a series of small points on the anterior margin of the vertex, between the ocelli. Known larvæ margined or banded.
 - c. Clavus with a series of reticulations between the outer nerve and the suture; species fuscous, with black points on the vertex, elytral nervures light.
 - d. A pair of large, round, black points on anterior margin of each, vertex, pronotum and scutellum; length four mm..... *inimicus*.
 - dd. Points small, usually confined to the vertex, species shorter, length three mm.
 - e. Elytra distinctly longer than abdomen, vertex acutely produced in the middle; male plates convexly pointed, width at middle two-thirds their length. *weedi*.
 - ee. Elytra about equaling abdomen, vertex more obtusely rounding, male plates concavely attenuate, four times as long as width in the middle.. *compactus*.
- cc. Clavus without reticulations along suture; species black, with white points on vertex, outer two apical veinlets white, costa yellow..... *flavocostatus*

DELTOCEPHALUS BILINEATUS G. & B.

Hemiptera of Colorado, p. 85.

This species is very closely related to the *European D. formosus*, and like it, is very variable in color, ranging from almost black through distinctly black-striped forms to red-striped forms with black spots, and even on to those in which the black is almost wanting. It may be readily distinguished, whatever its color, by the reflexed white veinlets and its narrow elongate front. The dorsal stripes are always indicated, though variously colored and spotted. The general ground color beneath is some shade of yellow and the long plates of the male are broadly black tipped. This species was described from Colorado and has been collected at Ames, also in New Hampshire by Professor Weed. The Iowa specimens were taken in July from the undergrowth in a woody pasture where *Scaphoideus jucundus* occurred, which species it sometimes closely mimics.

DELTOCEPHALUS ALBIDUS N. SP.

(Pl. xxiii, Fig. 1.)

Clear milky white; a transverse line on the middle of the vertex, a circle around the tip and four stripes on the pronotum, black. Elytra flaring with reflex, dark margined costal veinlets. Length, 4.25 mm. Width of elytra on center of costa, 1.75 mm.

Vertex rather more than twice longer on middle than at eye, longer than width between the eyes, anterior angle slightly acute. Front broad, strong, twice wider on ocelli than at clypeus, sides straight, angle of the vertex less than forty-five degrees; genæ short, rounding, outer angle obscure; pronotum two and one-fourth times wider than long, feebly emarginate posteriorly; posterior angle indefinite. Elytra flaring, without an appendix, obtusely rounding posteriorly; venation distinct, the two outer apical veinlets strongly reflexed to the costa, the third one at nearly right angles to the costa and with the apices of the second and third anteapical cells forming nearly a straight line to the tip of the clavus, thus leaving two costal cells and three terminal cells, of which the outer one is the largest.

Color: Pearly white; above, tip of vertex triangularly margined with dark; a transverse slightly curved line on vertex, four longitudinal stripes on pronotum, the inner pair continuing across the scutellum and extending forward on to the base of the vertex, where they diverge, dark brown or blackish. Sutural and apical margins of elytra and anterior margin of the three outer veinlets lined with black. An oblique interrupted band from the tip of the scutellum to the center of the elytra, deep black. Tergum lined as in larvæ, the outer pair of stripes meeting above on the pygofers, forming a black V. Abdominal pleurites with a black margin and central dot.

Genitalia: Male valve large, acutely angled; plates twice the length of valve, narrowly, slightly concavely, pointed. Ultimate ventral segment of female twice the width of the penultimate; posterior margin divided into three broad lobes, central lobe notched one-half its depth. Described from numerous specimens.

Larvæ: Pearly white with four narrow brown stripes. Vertex acutely angled, three times as long on the middle as next the eye; body narrow; abdomen long, gradually tapering, acutely pointed. Color, pearly white above with two brown stripes arising just under the tip of the vertex passing up either side on to the disk, where they broaden, narrowing again toward the base, extending as narrow parallel lines ending abruptly on the posterior margin of the ultimate segment; a broad stripe on either side, arising behind the eye and extending back along the dorsum just inside of the white margin, meeting at the tip of the abdomen. A white spot on each abdominal segment within this stripe; a narrow white lined triangle on anterior third of vertex enclosing the point. Below, two stripes arising within the first pair just under the vertex, running broadly and obliquely across the face just under the eye, obscure or wanting on the thorax, margining the connexivum and meeting on the genitalia. Legs with small

round spots; posterior femora with a long dark line; middle femora with a transverse band below. These at rest complete the ventral stripe across the thorax.

This exceptionally well marked form may be easily recognized by its clear white ground color. It has been collected at Ames for several years but has not been received from any other locality.

The larvæ were first taken May 26th. They were then nearly full-grown and remained abundant for two weeks, disappearing by the middle of June. The adults were taken the 3d of June, and by the middle were exceedingly abundant, continuing in decreasing numbers up to the middle of July. The only appearance of a second brood was the capture of an adult male August 18th.

The field where this species occurred had been closely mowed June 25th, and the inference is that eggs had all been deposited in the grass stems above the point of cutting and must have been almost totally destroyed by the mowing. From these facts and through comparison with the life-history of other species their life-history may be, with reasonable certainty, completed as follows: Second brood of larvæ from the second week in July on to the middle of August; adults through August and September.

No definite food habit can be assigned, as there was a rich variety of native grasses where it occurred so abundantly. It was not, however, found on a field of *Andropogon scoparius* nor where the *Bouteloa*s predominated. Insectary tests to ascertain its food plant failed because of its great susceptibility to *Sporotrichum* in confinement.

DELTOCEPHALUS INFLATUS N. SP.

(Pl. xxli, Fig. 2.)

Form intermediate between that of *albidus* and *configuratus*. Color very similar to *configuratus* usually a dark blotch in the third apical cell. Length, 4.25 to 4.75 mm. Width across center of costæ, 1.75 mm.

Vertex scarcely twice as long on middle as next the eyes, one and one-fourth times as long as broad. Front more than twice as wide at ocelli as at clypeus; facial angle acute, as in *albidus*; front less inflated. Pronotum short, weakly angled; elytra flaring, variable in length, usually exceeding the abdomen, venation similar to *albidus*, costal veinlets not as strongly reflexed, shorter.

Color, dirty yellowish-white to light fuscous with faint markings, tip of vertex ivory white, narrowly, interruptedly margined with dark, a line just

inside the margin before the ocelli, an obscure rectangular mark just on either side the center and an oblique spot near the base, brown. Pronotum and scutellum faintly lined. Elytra sub-hyaline, nervures light, sometimes faintly margined; oblique band reduced to two spots; usually a dark blotch in the third apical cell and reflexed nerves lightly margined. Below, dirty white; upper half of the face usually dark with white arcs. Tergum with four black stripes, outer pair widest at base.

Genitalia: Ultimate ventral segment of female very long, central fourth slightly produced, notched in the center, arcuated and dark colored each side of the notch. Male genitalia much enlarged; pygofer enlarged, inflated, spoon-shaped, their tips compressed; last tergite much enlarged, inflated, compressed laterally and terminally against the pygofer. Valve large, acutely angled, plates small, about twice the length of the valve, roundly pointed, distended, and sometimes notched at tip by the sharp edge of the pygofer. Described from eighteen specimens.

The enlargement of the male genitalia, though not peculiar to this species alone, is rendered all the more striking from the fact that it is ordinarily met with only in the males of short-winged forms usually placed in the genus *Athysanus*, while long-winged forms of the same species in that genus have genitalia of normal size. The males of this species, however, are all long-winged and have constantly deltocephaloid venation and enlarged genitalia.

This species very much resembles *reflexus*, but has a broader head, stouter vertex and longer elytra, giving it a linear rather than a wedge shape. Specimens have been collected at Ames for a number of years and two examples were received from Colorado through Professor Gillette.

Adults have been taken rather sparingly through the last half of June, rather commonly through the first week in July, and one battered specimen the first of August. No larvæ have been taken or food plant determined.

DELTOCEPHALUS REFLEXUS N. SP.

(Pl. xxii, Fig. 1.)

Form very similar to that of *albidus*, but the vertex is longer, narrower and more acutely angled and the elytra more round-ing. Light cinereus above, the upper half of the face sharply black, lower half white. Length, 4 to 4.50 mm. Width, 1.75 mm.

Vertex: Length on middle nearly three times that at eye, nearly twice longer than wide, anterior angle acute, tip blunt. Front narrower above than in *inflatus*, facial angle slightly more acute; genæ moderately full, outer angle distinct; loræ only meeting the extreme tip of front, enclosing the clypeus. Pronotum short, truncate behind, posterior angles indefinite; elytra flaring, without an appendix; costal veinlets reflexed, even more strongly than in *albidus*; third apical cell wedge-shaped, twice larger than anal, veins on clavus coalescent through the median third of their length.

Color: Soiled white to light fuscous above; tip of vertex ivory white; triangle with a black margin, line near the margin before the ocelli; rectangular spot on disk, an oblique spot at base of vertex, as in *D. inflatus* well marked, brown. Pronotum soiled white with faint indications of stripes; elytra sub hyaline, soiled yellowish-white, oblique band reduced to two spots, one on the clavus near the pronotum, the other between the first and second sectors unequally divided by the white cross nervure; apical and reflexed veinlets broadly white, darkly lined before as is also the outer apical margin; tergum broadly black at base, lined near tip; outer pair of lines approximate behind. Below upper half of face sharply black, light arcs more or less distinct; lower half sharply white; venter fuscous.

Genitalia: Ultimate ventral segment of female about half as long as broad, margin roundly produced in the center, notched. Disk light, produced part black, pygofers broad, short, brown, maculate with white. Male valve broad, obtusely pointed; plates broad at base, concavely, attenuately pointed, three times the length of the valve, equaling pygofers. Described from numerous specimens.

Larvæ resembling those of *albidus* in form and *sayi* in color, but with more definite stripes. Upper half of the face black.

Vertex: Sides acutely angled, point obtusely rounded; body slender, tapering, last abdominal segment, long, narrow. Color above, striped with olive and white, a narrow median white line from tip of vertex to the tip of abdomen slightly expanded on the last segment, a slightly wider light line margining the vertex next the eye on either side and running to the posterior margin of the penultimate segment of the abdomen; a narrow white margin on either side from behind the eyes to the last abdominal segment.

The pupæ have a small round spot in the outer light line near the anterior margin of the thorax and a larger oblique mark near the posterior margin of the wing-pads; base of both rows of hairs on the abdomen with small round white spots. Below: Face, upper half black, lower half sharply white, as in adult, the dark line continuing along the femora and connecting with them as in *abidus* larvæ.

This species and the three following strongly resemble each other. They are most accurately separated by the structure of the genitalia, which have proved to be very constant in the hundreds of specimens studied, as in fact they have for the whole genus, though tested by the study of nearly 5,000 specimens. It has been collected in abundance at Ames this season, and one Colorado example received from Professor Gillette.

It was taken for the first time, June 3rd, when it occurred as full-grown larvæ and adult males. By the middle of June the larvæ had disappeared and the adults were numerous, continuing so well into July. Small larvæ were found the third week in July, and from then on they were numerous until the second week in August, when they had become full-grown and begun to disappear. The adults appeared by the end of the first week in August, becoming abundant by the middle and continuing to

be found throughout the fall. One female, dissected October 26th, showed three fully developed eggs and no smaller ones, probably indicating that the rest had been deposited before then. This species occurs well distributed over the prairies, but has not been found on the field of *Andropogon scoparius*.

DELTOCEPHALUS PECTINATUS N. SP.

(Pl. xxii, Fig. 3)

Form and color nearly of *reflexus*, slightly smaller; vertex distinctly shorter; face all dark. Distinctly separated by the venation and genitalia. Length, 3.50 to 4 mm.

Vertex two and one-fourth times as long as next eye, one-half longer than wide, sides slightly acute, tip nearly pointed; front short, more inflated than in *reflexus*, similar to *albidus*; clypeus short, narrowed at apex, width at base equaling length; loræ broad, sutures strong; pronotum two and one-fourth times wider than long, truncate behind. Elytra less flaring, slightly shorter than in *reflexus*; venation on corium similar; third apical cell smaller or only equaling the anal; veins on clavus not coalescent; abdomen very broad, depressed.

Color: Sordid yellowish-white above, markings as in *reflexus*; the oblique line on anterior margin of vertex nearer edge, less distinct; elytral veinlets not as strongly margined. Below: Face usually all dark, at least no distinct line of separation of color when lighter below; front always dark or fuscous to the base; tergum as in *reflexus*; venter usually darker.

Genitalia: Last ventral segment of the female less than half as long as broad, nearly truncate behind, with four narrow black comb-like teeth; pygofers more than twice as long as breadth at base, maculate; male valve equilaterally triangular, one and one-half times as long as their combined breadth at base, very slightly narrowing, obtusely rounding to truncate behind; shorter than the pygofers. Described from numerous examples.

Larvæ very similar in form and ornamentation to *reflexus*; color, olive green to fuscous, longitudinal stripes less distinctly marked; a white median stripe extending from vertex to tip of abdomen, widening on terminal segment, lateral stripes very obscure, often appearing as dots on the abdomen; body shorter and stouter, vertex shorter and broader, the oblique markings in the pupæ indistinct.

This is a slightly smaller and darker species than *reflexus*, the vertex is less pointed and the elytra inclined to be less flaring, giving it a more compact appearance.

The first adults were taken May 26th, becoming more numerous up to the middle of June, then decreasing in numbers into July. This species had not been recognized as distinct from the preceding until after the time for the first brood of larvæ, so no observations were made upon them. The first larvae recognized as belonging to this species were taken August 4th in a different locality from the preceding, and where *reflexus*

did not occur. They were then nearly grown, and the adults were beginning to appear. Two weeks later the adults were abundant and the larvæ gone. The adults continued abundant until into September, and could be found to the end of the season.

This species was taken wherever *B. hirsuta* was found, and never anywhere else during the season. *B. curtispindula* however usually occurs with *hirsuta* so that it could not be excluded on that ground, but the latter also occurs where *hirsuta* does not, and in no such locations has this species been taken as yet. Within the limits of the area it appears to feed indifferently on either plant, so that if restricted to the one it is probably a restriction of egg deposition.

DELTOCEPHALUS ABBREVIATUS N. SP.

(Plate xxii, Fig. 4.)

Form of *pectinatus* but much smaller. Smaller than *melscheimeri*. Light cinereus in color; length, 3 to 3.25 mm.; width, on center of costa, 1.25 mm.

Vertex shorter than in *reflexus*; slightly, roundly pointed, twice as long on the middle as next eye, about half longer than breadth between the eyes; front slightly proportionately longer than in *reflexus*, side straight; clypeus longer than broad at base; pronotum very short, truncate behind; elytra variable in length, without an appendix; veins on clavus not united; outer apical cell smaller than anal.

Color, light cinereus, above; markings as in *reflexus* strong; triangle around the white tip complete, broad; oblique line on margin usually reduced to a dot midway between the ocelli and tip; transverse band nearly complete; slightly crescentiform; oblique spots at base of vertex usually strong, sometimes a row of spots near the front margin of the pronotum. Elytra light cinereus, nearly all the nervures fuscous margined; apical cells and anterior margin of reflexed veinlet broadly black margined; tergum dark at base, two apical segments creamy white, with a V-shaped black margin in the female. Below, front fuscous; clypeus, loræ and genæ usually light with fuscous sutures; venter fuscous.

Genitalia: Ultimate ventral segment of the female twice wider than long, slightly emarginate posteriorly; middle fourth produced half its width, truncate, notched; arcuated and dark colored each side of the notch. Male, last ventral segment very short; valve large, acutely angled, much longer than the segment; plates broad, convexly pointed; about twice the length of the valve; pygofers elongate, narrow, much exceeding the plate. Described from numerous examples.

Larvæ: Resembling those of *reflexus* but much smaller in size. Color, olive green to fuscous; dark markings broken up into quadrate areas with fuscous margins. Vertex acutely pointed; body short, broad, abruptly terminated; median line narrow, broadening on the abdomen, where it is obscure; lateral lines usually complete; a transverse line on the vertex,

one-third the way back from the point, white; vertex light margined, except posteriorly.

Pupæ with oblique mark and spot in lateral white line present but obscure. Below, as in *reflexus*, dark marks nearly black.

This is the smallest species of the *reflexus* group; this and its cinereous color will enable one to separate it from *pectinatus* to which its dark face allies it, and which separates it from *reflexus*, or it may be readily separated from either by its genitalia. It has been collected abundantly at Ames, but it is not known from any other locality, although doubtless it will be found to occur with the other members of the *reflexus* group throughout the range of the *Bouteloas*.

Adults and full grown larvæ were first taken in company with the preceding species from *Bouteloa hirsuta* August 4th and 8th, 1896. By the middle of the month larvæ had disappeared, adults continuing numerous throughout the month and on until the middle of September. The spot where this species was found was a high gravelly pasture, the tops and sides of the knolls being covered with this grass, to which it seemed strictly confined.

DELTOCEPHALUS OCELLARIS FALL.

Cicada ocellaris, Fall. Hem. Suec., II, p. 20, 13 (Vide Melichar).

This is a much stouter and darker species than *sayi*, occurring commonly throughout central Europe, and has been received from Colorado. The vertex is much broader than in *sayi*; width between eyes nearly equaling length; pronotum very short; elytra very broad; nervures strong; clavus reticulated, central anteapical usually unequally divided. Color much darker than in *sayi*; light markings on vertex variable, not concentric; face dark, an inverted white T on apex of front; venter and genitalia shining black. Readily separated by the immense, convexly inflated shining black valve and the large, convexly margined plates of the male. Length, 3.50 mm. Width, 1.50 mm. The Colorado specimens were taken by Professor Gillette in Laramie county, July 5th.

DELTOCEPHALUS SAYI FITCH.

(Pl. xxiii, Fig. 2)

Amblycephalus sayi Fitch. Homop. N. Y. State Cab., p. 61.

Jassus sayi Walk. Homop. IV, p. 1158, 1852.

Deltocephalus sayi Uhler. Bull. U. S. Geol. and Geog. Surv., IV, p. 511, 1873.

This species may be swept sparingly almost everywhere, but occurs throughout the summer in immense numbers on blue grass in woody pastures, either high or low.

The adults are short and compact, with a rounding pointed vertex and broad, almost truncate elytra. In color they are rich brown with the tip and two concentric bands on the vertex lighter, and two bands of lighter on the elytra, one at the base and a broader one back of the middle. On these bands the nerv-ures are distinctly white. In form and ornamentation closely resembling *D flori* Fieb, but readily separated by the genitalia. Length, 3.5 mm.

The larvæ are more elongated than those of *inimicus* and have a narrower and more definitely angled vertex. They are colored very much as in the adult, but the markings are different. There is a narrow median line of white extending from the tip of the vertex to the last abdominal segment, where it broadens and nearly covers the tip; the inner margin of the eyes, a concentric band near the point of the vertex, and two spots just back of the center on either side are lighter. A broad marginal stripe from the eye back, an indistinct, narrow one from the inner margin of the eye, which may break up into white spots, one on the posterior margin of each abdominal segment, and a second row of dots midway between the first and the marginal stripe on either side, complete the white markings of the body. The face is light with fuscous striations.

The larvæ were first taken sparingly from upland prairie the second week in June. They were full-grown and were probably belated ones, as the adults had been taken during the first week. On June 16th the first observation on wooded pastures was made and the adults were swept in immense numbers from rank blue grass. They continued to be found in great numbers whenever observed throughout the remainder of the season. The larvæ were next observed July 11th, when they were somewhat over half-grown, and by the last week in July they were full-grown; abundant, and fresh looking adults were also numerous. Again on the 5th of September nearly full-grown larvæ were observed to be numerous, as also were the adults. Later in the month the larvæ were becoming rare and the adults still very plenty, as they continued to be throughout October. Six females dissected on the 27th of October showed no signs of eggs, from which it might be inferred that they had been deposited. On this assumption, which coincides well with the early appearance of the spring brood of larvæ, the following arrangement of broods would seem very probable and harmonize well with the dates given above.

First brood of larvæ through May and the first week in June, adults from the last week in May until the middle of July; second brood of larvæ, last week in June until the first week in August; second brood of adults from middle of July through

August; third brood of larvæ from middle of August until the last week in September; third brood of adults from the first week in September through October.

DELTOCEPHALUS CONFIGURATUS UHL.

(Pl. xxlii, Fig. 3.)

Bull. U. S. Geol. and Geog. Surv., IV, p. 511, 1878.

This widely distributed species is the largest of the genus in America, and though the coloration is often so faint as to leave it almost unicolorous above, it may be easily recognized by its broad, blunt head as well as by its peculiar genital structure. The last ventral segment of the female terminates in an attenuate bifid black process, and the male plates are strong, broad and obliquely truncate.

In the definitely colored individuals there is a white cross on a white margined vertex of fuscous and alternating light and fuscous stripes on the pronotum. The nervures of the elytra are white, margined more or less strongly with fuscous. The elytra vary in length, usually longer than abdomen. A median impressed black line on the vertex is never entirely wanting. Length, 4.50 to 5 mm. Closely related to *D. bohemani* Zett, but with male plates distinctly shorter, and not laterally excavated.

The larvæ may be separated from *sayi* by the broader head, rounder vertex and stouter form and from any other of the striped larvæ by the fuscous striated front. It is of a pale brown above, with three indistinct stripes and a row of dots just inside the narrow light margin on either side of the abdomen. Front light, with indistinct fuscous striations.

This species was first taken in great abundance as full-grown larvæ and freshly issued adults on May 2nd and 12th. Within two weeks the larvæ had all disappeared, while the adults were very numerous throughout June, and a few were found in July.

This species occurred with *albidus* on the field that was mowed June 25th, and as recorded for that species, was practically exterminated by the process. Though the field was under continual observation throughout the remainder of the season the only indication of a second brood was the sweeping of a half grown larva July 16th. These facts indicate that it has a very similar life-history to *albidus*, the broods however occurring from one to two weeks earlier, the second brood of larvæ probably appearing the last week in June and continuing through July; the second brood of adults from the last week in July

through August, larvæ again appearing sometime in September, going through the winter to appear again as adults in May.

Facts which materially strengthen these conclusions are that while in these two species exterminated, known facts in their life-history indicate that the eggs would have been deposited before this time, and would thus be subject to destruction, while other species occurring on the same area, whose eggs are known to be deposited at other periods, remained abundant throughout the season. That close mowing at the proper time was an effectual check seemed to be thoroughly demonstrated for these two species. There would be a second period, when the eggs of the second brood might be destroyed, occurring, according to the above determinations, toward the last of August.

DELTOCEPHALUS DEBILIS UHL.

(Plate xxiii, Fig. 2.)

Deltocephalus debilis Uhler. Bull., U. S. Geol. and Geog. Surv., II, p. 360, 1876.

Deltocephalus minki Fall. Provancher. Pet. Faun., III, p. 279, 1889.

Although this is a very variable species in color, size and genital characters, and approaches in its different variations three recognized European species, *abdominalis*, Fab., *falleni* Fab., *minki* Fieb., the intergradation of these varieties prevents their separation, for this country at least. An examination of the European material at hand indicates a similar variation in their fauna.

This species may be briefly characterized as follows:

Color, usually deep green, more or less marked with black below, sometimes even appearing on the elytra. Vertex variable, more or less distinctly, acutely angled; length usually slightly greater than width; front strong, broad above; sides straight; loræ long; genæ with the lateral margins excavated below the eyes; outer angle very distinct, scarcely rounding below the clypeus; elytra, length variable, usually exceeding abdomen; venation distinct, central anteapical cell large, first anteapical narrow, elongate, nearly parallel margined.

Genitalia: Ultimate ventral segment of female varying from rounding behind with a deep notch to nearly truncate, slightly lobed each side of a shallow notch. Male valve obtuse, variably exposed; plates very broad at base, slightly longer than wide, bluntly, obtusely pointed, lined or spotted with black; length, 4 mm.

This well known species is comparatively rare at Ames, a few specimens being taken each year. During this season adults were taken from the first week in June until the first week in July, usually found in wooded regions.

DELTOCEPHALUS MINIMUS N. SP.

(Plate xxiv, Fig. 4.)

Form and color of *debilis*, but less than half the size; length of vertex more variable even than in that species; the smallest species in the genus; length, female, 2.75 to 3 mm.; male, 2.25 to 2.50 mm.

Vertex very variable in length, usually convexly and acutely pointed in the female, longer than the pronotum; roundly rectangular in the male, about equaling the pronotum; front strong; similar to *debilis*, broader on the clypeus; clypeus broad, one-half longer than wide; loræ broad, nearly semi-circular; genæ much narrower than the eyes, lateral margin short and straight.

General color like that of *debilis*; vertex, margins of the pronotum and scutellum yellowish-green; disk of the pronotum and basal part of the elytra dark green; apical portion of the elytra lighter. Below, front fuscous with lighter arcs, rest of face greenish; tergum and venter greenish or fuscous, varying to black; legs usually distinctly black below.

Genitalia: Ultimate ventral segment of female broad; posterior margin roundly produced from the lateral angles, narrowly arcuated and notched medially, black tipped; pygofers nearly twice as long as width at base, equaling the black ovipositor; male valve large, triangular; plates broad, convexly pointed, three times the length of the valve, usually a dark spot beyond the middle of each. Described from numerous examples.

Larvæ: Small dark green forms with acutely pointed vertices and black faces and eyes; vertex convexly, acutely pointed; body long, tapering from eye back to tip of abdomen; hairs on abdomen distinct; green above, vertex lighter, ocelli black. Below, all dark fuscous to black in the later moults, especially noticeable on legs.

This very small and distinct species occurred abundantly on a patch of raw prairie adjoining the *Adropogon* field, where the *oculatus* occurred so thickly, and was found at the same time and in the same stages as that species throughout the season, but did not occur on the isolated *Andropogon*. *Sporobolus heterolepis* and the *Stipa* were very plentiful, where they were most abundant, either one of which would harmonize well with its green color.

DELTOCEPHALUS MELSCHEIMERI FITCH.

(Plate xxiv, Fig. 1.)

Amblycephalus melscheimeri Fitch. Homop. N. Y. State Cab., p. 61.

Deltocephalus debilis Osborn. Bull. Iowa Exp. Sta. No. 13, p. 100; No. 20, p. 714.

Deltocephalus affinis Gillette and Baker. Hemiptera of Colorado, p. 84.

Deltocephalus auratus Gillette and Baker. Hemiptera of Colorado, p. 85 (Female).

This is a slightly smaller species than *debilis* and with more general fuscous markings.

Vertex one-half longer on middle than at eye, width between eyes greater than length; obtusely, slightly roundly angled. Front narrower

below than in *minimus*; genæ long, not distinctly angled outwardly. Elytra narrower than in *debilis*, venation similar, outer anteapical cell short, rounding; ultimate ventral segment of female short, truncate behind, usually medially depressed, giving it a strongly, angularly excavated appearance; male valve large, inflated, rounding posteriorly, concealing all but the tip of the short plates. Color varying from pallid, with subhyaline elytra to fuscous, with heavily fuscous margined elytral nervures; tergum venter and male genitalia black; length, 3.75 mm.

Larvæ, form of those of *inimicus*, nearly; vertex longer than broad, definitely angled; body stout; abdomen short; color light yellow, much lighter than the dorsal color in *inimicus*, without markings of any kind.

This is a widely distributed and well known species, occurring in immense numbers on blue grass in lawns and open pastures, and frequently met with in various other open situations, never occurring, however, very far within the margin of shaded areas, where it gives place to *sayi* and *Athysanus curtisii*.

Work was not commenced early enough to determine fully the life-history, but broods the past season were recognized on blue grass as follows: Adults from the middle of May until the last of June; larvæ from the first week in June till the middle of July; adults from the first week in July through August; larvæ through August until the middle of September; adults from the middle of September through the season.

It is the only American representative of a series of species with enlarged male valve and concealed plates, and is thus rendered very distinct in our fauna. The closest allied form seems to be the European *D. striatus* L., with similar recorded habits.

DELTOCEPHALUS OCULATUS N. SP.

(Pl. xxiii, Fig. 4.)

Form and size very close to that of *melscheimeri*, slightly smaller, resembling the European *D. metrius* Flor in size and color, but with a sharper vertex. Length, 3.50 mm. Width, .90 mm.

Vertex variable, at least one-third longer than broad, one and one-half times length next eye, convexly pointed; front broad, straight margined; genæ arising from the outer corner of the eye, moderately curved below; elytra long and narrow, similar in form and venation to those of *melscheimeri*, but with nervures less distinct.

General color of the female light yellow; eyes and tip of last segment purplish black; male slightly greenish-yellow; tergum and venter darker front with fuscous arc and in fall broods the vertex is marked with brown.

Genitalia: Ultimate ventral segment of the female short, lateral angles slightly acute, central half of posterior margin narrowly produced; length of produced part equal to its width at apex; apex with three lobes indicated, produced part dark colored; male valve triangular, shorter than broad,

plates broad at base, rapidly, roundly narrowing to the narrowly produced, black-tipped points. Described from numerous specimens.

Larvæ: Tawny yellow, sometimes with light fuscous marking; a bright purple spot on either eye in life or in freshly mounted specimens; vertex narrow and longer, more acutely pointed than in *melscheimeri*; body narrower more gradually tapering. In general color is more intense than in *melscheimeri*, and approaches *inimicus*; late or exposed forms sometimes distinctly fuscous marked. Living specimens are readily separated by the distinct purple spot on the eye.

This species has been received from Colorado, and has been collected at Ames prior to this season. It was first taken this year as adults the last week in May, and from then on through July. Larvæ were taken abundantly during the second and third weeks in July, disappearing by the end; adults were again found from the middle of July through August; larvæ again appearing in August, maturing through September; adults from the first of September on through the season.

It has been found everywhere on *Andropogon scoparius*, to which it seems strictly confined. Mowing during the middle of June and again the first half of August, or burning during the fall or spring would serve to check this species.

DELTOCEPHALUS SYLVESTRIS N. SP.

(Pl. xxv, Fig. 4.)

Form and venation nearly of *D. cinereus*, but with a longer vertex. Form and size of the European *repletus*, but differing in venation. Length, 3.50 mm. Width, 1 mm.

Vertex twice as long on the middle as next eye, longer than the pronotum, nearly twice longer than wide, acutely pointed; front long, narrow, much longer than wide, hardly half wider at ocelli than on clypeus; clypeus strong; loræ broad, prominent. Pronotum long, more than half as long as wide; posterior angles strong; elytra long, narrow, nervures distinct, venation as in *debilis*, outer anteapical long, narrow, distinctly more than half the length of the middle one.

Color: Greenish, marked with pale fuscous and brown; vertex light green with two more or less distinct brownish stripes; pronotum green, light margined; elytra greenish, nervures light, more or less fuscous margined; never with a whitish cloud, as in *cinereus*; tergum black at base; front fuscous with light arcs, clypeus light; loræ and genæ with fuscous and light margins.

Genitalia: Ultimate ventral segment of the female light colored, long, slightly narrowing posteriorly; the middle third abruptly produced one-half its width, produced part longer at the margin, not notched or rounded as in *cinereus*, distinctly black; male valve broadly triangular, apex pointed; plates three times the length of the valve, broad at base, concavely pointed, tip divergent, a dark line near the outer margin widened to a spot near the middle.

This is a widely distributed species, having been received from Maryland and Kansas. Specimens are in the VanDuzee collection from Ontario, and it has been taken at Ames for a number of years. It occurs only on blue grass in wooded areas, where it may be found in immense numbers. It was first observed this season, June 4th, in considerable numbers, and from then on nearly through July. Observations were not made again until September, when it was found as thick as ever. The larvæ were not successfully separated from those of other species occurring in the same location and so no separation into broods can be made at present.

DELTOCEPHALUS CINEREUS VAN D.

Trans. Am. Ent. Soc., XIX, p. 304, 1892.

This is a neat, compact little species, slightly stouter in appearance than *melscheimeri* and of a distinctly fuscous or cinereus cast.

The vertex is twice as long on the middle as next eye, length and width about equal, tip acutely produced, pale fulvous brown, with narrow margins and a broader median line enclosing a black impressed line, white; elytra with cinereus nervures, heavily margined with fuscous.

Genitalia: Ultimate ventral segment of female slightly rounding behind, distinctly notched in the center, slightly arcuated and deeply black either side of the notch; male valve produced, sides emarginated, apex obtusely rounding; plates more than twice the length of the valve, convexly pointed.

Specimens of this species have been received only from California, from which place it was originally described. This species and the preceding one are closely allied, but may be readily separated by the length of the vertex and the female genitalia, as well as by the difference in color.

DELTOCEPHALUS AURATUS G. & B.

Hemiptera of Colorado, p. 85.

The female described under this name by Gillette and Baker (Hemiptera of Colorado, p. 85) was evidently a freshly issued example of *melscheimeri* as may be readily determined by comparing his description and drawing with the descriptions and drawings of *D. affinis* on the preceding page of same work, *affinis* being also a synonym of *melscheimeri* as proved by examination of typical specimens of both sexes. The male *auratus*, however, is a very distinct species, with a more roundly margined vertex, and narrower front and clypeus.

The elytra are very long, overlapping, with a distinct appendix, the center anteapical cell greatly elongate, posteriorly extending much beyond the adjacent cells; valve broad, short, about equaling the ultimate segment; plate broad at base, about three times the length of the valve, slightly narrowing, with straight margins to the broad truncate apex; styles bristle-like, exceeding the plates; pygofers with numerous strong spines below. Color: face and vertex orange red, pronotum and elytra yellow, sometimes with a reddish cast; venter and genitalia light yellow, plates narrowly black-tipped.

DELTOCEPHALUS SIGNATIFRONS VAN D.

(Plate xxv, Fig. 1.)

Trans. Am. Ent. Soc., XIX, p. 305, 1892.

D. sexmaculatus G. & B., Hemip. Col. p. 88.*

This species, which was described from Colorado, and has been received from Maryland, occurs very commonly at Ames. It very closely resembles *inimicus* in form and color, but is readily recognized by its smaller size, and the absence of the dots of the former species.

The adult is 3.50 mm. long, narrow, elytra elongate, closely folded, giving it a very narrow appearance posteriorly. Vertex with six more or less distinctly marked bars, anterior pair smallest; the nervure of the elytra alternately fuscous and lighter; central anteapical cell elongate, constricted, rarely, if ever, divided.

Adults were taken rather commonly May 29th, and again June 4th, no more being taken until the last of August, when they were again swept in fair numbers, and from then on until September 10th, when the last one was taken. They were most abundant upon weedy places, roadsides, etc., where *Setaria* and *Panicum* abound. Considering the nature of the food-plant no economic measures need be suggested, unless it should be found to occur on millet or Hungarian grass.

DELTOCEPHALUS INIMICUS SAY.

(Plate xxiv, Fig. 3)

Jassus inimicus Say. Jour. Acad. Nat. Sci., IV, p. 395, 1831; Compl. Writings, II, p. 382, 1869.

This species is almost universally distributed throughout the northern part of the United States and into Canada. It has previously been reported west to the Rocky Mountains, and

* On examination, the type specimen now in possession of Mr. E. P. VanDuzee proved to be an immature female of this species.

specimens are in hand from the state of Washington. It is readily recognized by its short vertex, elongate elytra, with the central anteapical cell divided, and the presence of six round black dots, a pair on the anterior margin of each, vertex, pronotum and scutellum; color, fuscous maculate. Ultimate ventral segment of the female narrowing posteriorly, margin twice indented, including a median obtuse tooth, outer angles rounding; male, ultimate segment slightly, angularly emarginate; valve short, obtusely angled; plates narrow, acutely pointed, equaling the pygofers.

Larvæ: broad, stout-bodied, with blunt, obtusely rounded heads; color yellow, with a broad, black margin behind the eyes.

The life-history of this species has already been given. Further observations during the past season confirm the idea of two broods as follows: Larvæ appearing about the first of May and maturing before the middle of June; adults from the first of June to the middle of July; the second brood of larvæ appearing before the middle of July and mostly matured by the third week in August, adults again from the second week in August on through September.

This species has a wide range in food habit and consequent variability in its life-history. The limits given above are for blue grass broods, where it is under nearly constant conditions and seems to be reasonably definite in its appearance. Its occurrence on annuals would be materially affected by the date of their appearance.

DELTOCEPHALUS WEEDI VAN D.

(Plate xxv, Fig. 2.)

Trans. Am. Ent. Soc., XIX, p. 306, 1892.

This pretty little species has also, probably, a very wide range, though only reported as yet for Mississippi. It also occurs at Ames.

Adults measuring about 3 mm., with a bluntly produced vertex, sides sharply concave, elytra slightly longer than the abdomen, flaring; central anteapical cell divided, color testaceous brown, with the anterior portion of the vertex and nervures of the elytra light; four dark points on anterior margin of vertex, front and venter dark; male plates short, together nearly circular in outline.

This species was taken at Ames in June, but no determination as to its life-history has been made.

DELTOCEPHALUS COMPACTUS N. SP.

(Pl. xxv, Fig. 3.)

Form and coloration similar to *weedi*, though with a shorter, blunter vertex and shorter elytra. Length, 2.75 mm. Width, 1.25 mm.

Vertex one-half longer on middle than next eye, slightly longer than broad, tip bluntly, slightly, convexly pointed; disc of the vertex slightly rounded; front inflated, broadest in the middle, rounding above and below; clypeus straight; genæ narrow, arising within the middle line of the eyes, scarcely angled; pronotum large, equaling vertex in length, posterior angles strong; elytra strong, convex, about equaling the abdomen in length, nervures strong, white, usually numerous strong reticulations between the outer claval nerve and the suture; central anteapical cell divided, posterior division usually circular in the shorter-winged specimens, resembling *ocellaris* in this respect.

Color: General appearance maculate brown; vertex light yellow with variable black and brown markings as follows: A black crescentiform interrupted band between the front margins of the eyes, a pair of approximate points near tip, and another pair just inside the black ocelli, dark brown; behind the crescentiform band on either side the median impressed black line, a circular light brown spot, which may be emphasized on the lateral margins when they appear as crescentiform dashes; pronotum dark reddish-brown, more or less maculate before; two faint wavy white lines across the disk; scutellum yellowish-brown, two dark spots on the disk; elytra brownish fuscous; nervures broadly white and fuscous; below, dark with white sutures, to black.

Genitalia: Ultimate ventral segment of female deeply, circularly emarginate behind, concealed except the acute lateral angles by a circular subhyaline membrane arising from the base of the segment and extending medially beyond the lateral angle. Male valve small, inflated, rounding posteriorly; plates broad at base, rapidly, concavely narrowing to the long attenuate points, exceeding the pygofer. Described from forty-seven specimens.

This species has been received from the state of Washington and collected at Ames the past season.

Adults were first taken June 27th, when they were swept rather sparingly from two different patches of *Sporobolus hookeri*. They were taken from that time on till July 27th, and then again, probably of a different brood, August 15th and 19th, the latter ones, however, from a different locality, as the first two patches had been mown before that time.

DELTOCEPHALUS FLAVOCOSTATUS VAN D.

Canadian Entomologist, XXIV, p. 116, 1892.

This species was described from Mississippi; specimens are at hand from Ohio, North Carolina and Georgia, and it has been collected at Ames for a number of years and is recorded from

Washington, D. C. This appears to be an abundant form in the south and is apparently reaching its northern limit in Iowa, occurring, however, in marvelous abundance in hot sheltered locations and on southern exposures where the vegetation is short and the ground hot.

The adults are readily recognized by their deep, testaceous brown or black ground color, with a series of points on the anterior margin of the vertex, extending down to the antennal pits on either side and the two outer apical veinlets, white. The legs and a narrow marginal stripe on the basal half of the costa yellow. The head is short and rounding, the elytra long; central anteapical cell divided. Ultimate ventral segment of the female rounding posteriorly, slightly produced in the middle; male valve broad, convex, obtusely, concavely pointed; black, with a narrow yellow margin; plates two and a half times the length of the valve, bluntly pointed, margined with yellow bristles.

Larvæ: Quite as distinctly marked as the adult and are easily separated from any other form. They are two to two and one-half millimeters long, when full-grown, very stout built, head broad and short as in the adult. Color above a rich olive brown with three white bands as follows: One on the posterior margin of the thorax, complete in the larvæ but only visible between the wing-pads in the pupæ, a narrow interrupted one on the middle of the abdomen, and a broader one near the tip; each abdominal segment margined posteriorly with red, just in front of which there are four white dots arranged in longitudinal rows where not obscured by the white markings; eyes, area between the posterior bands and tip of abdomen darker, approaching black; beneath pale, with tip of abdomen and posterior tibiæ darker.

The adults were taken first June 20th, on a field that had just recently been seeded down and on which weeds were springing up very thickly. On July 27th the same spot was abounding in full-grown larvæ, pupæ and adults; the larvæ and pupæ disappearing within a week, adults continuing abundant from then on into and through October.

DELTOCEPHALUS NIGRIFRONS FORBES.

Cicadula nigrifrons Forbes. 14th Rept. Ill. State Ent., p. 67.

D. fusconervosus Van D. Bull. Buffalo Soc. Nat. Sci., V, 207, 1894.

Thamnotettix perpunctata Van D. Bull. Buffalo Soc. N. Sci., V. No. 4, 1894.

Deltocephalus vanduzeei Gillette and Baker. Hemiptera of Colorado, p. 90.

The specific limits and generic position of this species are very puzzling and have led to much confusion and synonymy

It has not been thought best at present to change the generic reference given by VanDuzee, although not included in the synopsis. With a more exact definition of the American genera which will be possible as our species are better known, this and some other aberrant forms of a generalized and plastic character may find their proper position.

It was first described by Forbes as a *Cicadula* from specimens with weak venation. VanDuzee received dark specimens of the green form from Mississippi and described them as *Thamnotettix perpunctata*; also describing a strong veined form from California with two cross nervures as, *D. fuscinervosus*. Gillette and Baker, from very dark forms, described *D. vanduzeei*.

Larvæ and adults were found in immense numbers about the first of July. The larvæ had mostly all issued by the 10th, the adults continuing through the month; adults were again taken late in September and on into October. They were first found on a patch of plowed ground overgrown with *Panicum sanguinale* and *crus-galli*, and *Setaria viridis*. Here they occurred in immense numbers. They appeared to be more common on the annuals than on the perennials, but were taken almost everywhere, the later ones mainly from blue grass, the annuals having ripened and died. Professor Forbes described it as a serious pest of oats and in *Insect Life*, vol. VI., it was recorded as very abundant and destructive in lawn grass in Washington, D. C.

Where first found this season it occurred in two distinct forms about equally common, one with a single cross nervure and long elytra as in *Thamnotettix*. This form was light greenish-yellow with a light face, usually surrounded by an arch of dots above on the anterior margin of the vertex and two oblique dots on the disk of the vertex. The other form was cinereus, darker below, with shorter hyaline elytra, usually with two cross nervures and the central anteapical cell divided. These may probably be regarded as the equivalents of long and short-winged forms in other species, the smaller darker form with the more complex venation, being found almost everywhere, while the lighter form with the weak venation was only found in connection with the larvæ and apparently made little use of the wings.

The specific characters differ very little between the different forms, the variations in genitalia being similar to those in the long and short-winged forms of other species.

The vertex is short, obtusely angled, margins rounding to the front; a row of dark spots on the anterior margin extending down the face to the

antennæ; the spots on the vertex more or less united and merged into bands connecting with the oblique bands on the disk in the darker forms the front is roundly inflated, the margin continuous with that of the clypeus; clypeus broadest below. The dark markings on the front heighten this appearance by rounding away from the sutures above on the front and expanding on the clypeus below. While these two forms are fairly constant they so intergrade in structure and color as to render separation impossible. Late specimens of the green form being often similarly marked and even more highly colored than early ones of the fuscous form; while early examples of the fuscous form often possess a venation even weaker than that of the green form and would be readily mistaken for *Cicadula*. Moreover, there is no distinction in the larvæ which produce them.

Larvæ: Form nearly that of *flavocostatus*; slightly narrower and more elongate, approaching those of *exitiosa*. More distinctly yellow than those of *D. ocellaris*, unmarked except two black dots on the margin of the vertex midway between the eye and the tip and a pair of oblique dashes on the disk of the vertex. The pupæ have in addition to these three spots on the anterior margin of the wing-pads and a number on the posterior half of the disk more or less definitely arranged in transverse rows.

A very widely distributed and abundant species. Specimens are at hand from New York, Maryland, Mississippi, Louisiana, Illinois, Iowa, Colorado and California.

DELTOCEPHALUS ARGENTEOLUS UHL.

Deltocephalus argenteolus Uhler. Bull. U. S. Geol. and Geog. Surv., III, p. 473, 1877.

Athysanus curtipennis Gillette and Baker. Hemiptera of Colorado, p. 92.

Eutettix terebrans Gillette and Baker. Hemiptera of Colorado, p. 102.

The short-winged forms of this species are very close to the European species of the genus *Doratura*.

D. MONTICOLA G. AND B.

Hemip. Col. p. 88.

This is a good *Deltocephalus*, but specimens came to late to allow of its insertion in the synopsis. It would follow *D. minimus*, which it closely resembles in size and coloration, but from which it is readily separated by the presence of a distinct median tooth on the last ventral segment of the female.

DELTOCEPHALUS MINUTUS VAN D.

Entom. Amer. VI, p. 96, 1890.

This species was described from a long-winged male, but it occurs in both long and short-winged forms very abundantly. The short-winged examples apparently fall into the genus *Doratura*.

DELTOCEPHALUS OSBORNI VAN D.

Trans. Am. Ent. Soc., XIX, p. 304, 1892.

This species should be placed in *Athysanus* and close to *extrusus*.

DELTOCEPHALUS SIMPLEX VAN D

Trans. Am. Ent. Soc., XIX, p. 304, 1892.

This and the three following species should be placed in the genus *Thamnotettix*.

DELTOCEPHALUS COQUILLETHI VAN D.

Entom. Amer., VI, p. 95, 1890.

D. CONCENTRICUS VAN D.

Deltocephalus concentricus VanDuzee. Bull. Buffalo Soc. Nat. Sci., V, p. 203.

Thamnotettix flavomarginata Gillette and Baker. Hemiptera of Colorado, p. 96.

D. BIMACULATUS G. AND B.

D. bimaculatus Hemiptera of Colorado, p. 86.

D. flavovirens, G. and B. Hemiptera of Colorado, p. 87.

DELTOCEPHALUS UNICOLOROUS G. AND B.

Hemiptera of Colorado, p. 89.

Probably an immature specimen of their *monticola*.

ATHYSANUS CURTISII FITCH.

Amblycephalus curtisii Fitch. Homop. N. Y. State Cab., p. 61, 1851.

This species is the best known and the most widely distributed member of the genus occurring throughout the Eastern States and Canada, and as far west as Michigan and Iowa at least, probably to the mountains. The adult is three and one-half millimeters in length by one and one-half broad, with the vertex scarcely longer than the width of the pronotum, obtusely convexly pointed; elytra exceeding the short ovipositor; color, vertex yellow, with large round spots before the middle, and tip black; face yellow, an oblique black band extending from either eye to the base of the clypeus, then prolonged narrowly to the tip, forming a Y-shaped mark; the pronotum yellowish-green, with a black crescent, anteriorly; elytra dark, nervures yellowish-green.

Larvæ stout, with a large, convexly conical head. Of a deep yellow color, with eyes and antennæ dark. The body is covered with long stout hairs.

This species is confined strictly to blue grass in meadows and wooded pastures, where it rivals *D. sayi* in abundance. First collected this season, June 17th, as adults in abundance; the larvæ were found during July, becoming full grown and issuing as adults by the end of the month. Another brood of larvæ matured during September, the adults continuing through the rest of the season, becoming scarce by the last of October, when a dissected female showed one fully developed egg, the rest probably deposited.

ATHYSANUS BICOLOR VAN D.

Canadian Entomologist, XXIV, p. 114, 1892.

This species was described from Kansas and Mississippi, and had been reported from Iowa under the name *virgulatus* Uhl (a MSS. name). The adults have nearly the same form and size as the preceding species; the vertex is more pointed and the attenuate ovipositor extends beyond the elytra.

In color the females are yellowish green, with two large coalescent spots on the vertex, both margins of the pronotum, the entire claval suture and the tip of the wing black; below, all light. The males have the whole point of the vertex the sutural margin and an oblique band from the anal cell to the center of the costal margin black. Below all black except a band across the middle of the face. It can be readily separated from *curtisii* by the absence of the Y on the face, and the fact that the yellowish-green of the elytra is not confined to the nerves.

The larvæ are very light yellow, sometimes almost white, and the hairs are much smaller and finer than those of *curtisii*, which, otherwise, they closely resemble. They were first taken June 16th, when the first adults of a brood were issuing; larvæ remaining abundant until the end of the month. The adults were very thick until well into July, disappearing before the end; appearing again toward the end of August and through September. They were thickest upon a patch of *Andropogon scoparius*, where it was nearly free from other grasses.

ATHYSANUS OBTUTUS VAN D.

(Plate xxi, Fig. 2)

Canadian Entomologist, XXIV, pp. 115, 156, 1892.

This species was described from Mississippi, and has been received from Kansas and taken at Ames prior to this season. The adults have almost exactly the form and size of *bicolor*, but are readily distinguished by their color. The vertex is lemon yellow, with two round spots just before the middle, and two small, oblique dashes near the base, darker. The remainder of the body is testaceous. Apical cells of the elytra hyaline, enclosing veinlets dark.

The larvæ are light yellow when small, but gradually darken to a chocolate brown in pupa, when they resemble the adults in form. The adults have been taken the last week in April, rather commonly, indicating an adult hibernation, the larvæ appearing in May, maturing the middle of June; the adults

remaining through June and the greater part of July. Full-grown larvæ were found toward the latter part of July and again before the middle of September; adults common throughout the season. This would indicate three broods during the season, the third one hibernating as adults, though the larvæ found in July may have been belated ones of the first brood.

The food plant is *Andropogon scoparius*, and it was not until late in the season that the larvæ of *D. oculatus*, *Athysanus bicolor* and the smaller light ones of *obtusatus* could be distinguished. Many confusing records interfere with the accurate determination of the later broods.

ATHYSANUS COMMA VAN D.

Canadian Entomologist, XXIV, 114, 1892.

This species was described from Iowa and has been received from Colorado. The adults are five millimeters long by nearly two broad, with a short flat vertex, color creamy white with four square spots on margin of vertex, two round ones near its base, four stripes on the pronotum, the claval suture black. A broad stripe within and parallel to the costal margin, reaching and covering the apical veinlets, curving back to meet a black stripe on the disk, cinnamon brown.

Larvæ have been referred to this species only with some doubt, and will not be described.

Adults were taken from May 27th until July 9th, most abundantly about the third week in June. They were again taken in August, however, not so abundantly. The spring brood was taken from *Elymus canadensis*, but no fall brood could be found on this plant, those taken in August being taken from *Elymus striatus*. On August 11th three partly grown larvæ resembling the adult except that they had only three stripes instead of four, were beaten from the heads of *Elymus canadensis*. This species is strictly confined to the *Elymus* as a host plant, but might damage other grasses near where it was abundant. Cutting the *Elymus* the first of July would destroy the eggs for the second brood.

ATHYSANUS COLON N SP.

(Pl. xxvi, Fig. 3.)

Form and general appearance nearly as in *comma*, clear, creamy white with dark stripe, occurs in two wing lengths. Length of female, 5 mm.; male, 4.25 mm. Width on costa, 2.25 mm.

Vertex nearly flat, one-half wider than long, shorter than pronotum, obtusely angled before, margin obtuse; front one-third longer than wide, width on clypeus more than half that at ocelli; clypeus narrow, nearly parallel margined; loræ large, wider than clypeus; pronotum more than three times wider than long, obtusely rounding before; side margins, one-half the length of the eyes; elytra occurring in two lengths, a short form in which the apical cells are minute, reaching only to the penultimate segment, this usually associated with rudimentary wings, the long-winged form with fully developed apical cells elytra exceeding the abdomen and associated with fully developed wings; venation simple, inner branch of first sector forked near its middle, making one more anteapical cell than in *comma*; four terminal and two costal cells.

Color: Clear, creamy white with testaceous and black markings as follows: Four quadrate spots on the anterior margin of vertex, the outer pair between the eyes and ocelli, two large round spots near the base of the vertex and a smaller irregular pair on the disk midway between these and the inner marginal pair, black; a small black spot under the base of the antennæ, four equidistant dark brown or black stripes on the pronotum, the inner pair extending across the scutellum; a small dash behind the eye and a stripe just under the lateral margin of pronotum, black; elytra with eight brown stripes, a complete longitudinal stripe just outside the first sector and another next the claval suture, a narrow stripe between the branches of the first sector, a shorter one between branches of its inner fork, a broadly interrupted one between the first and second sectors, a complete median stripe on the clavus, one on the outer, apical half and another on the inner, basal half. The apical cells and the apex of the anteapicals, fuscous margined. Tergum with four black lines posteriorly; pygofers with two round black spots above; connexivum broadly margined on the outside, narrowly on the inside, with black; legs lined and spotted with black.

Genitalia: Ultimate ventral segment of the female with the posterior margin angularly excavated; apex of excavation truncate, sharply notched, black; lateral angles acute; male valve narrow, apex rounding, one-half longer than the ultimate segment; plates slightly broader than valve at base, narrowing to the middle, then parallel margined to the broad truncate apex, twice the length of the valve, equaling the pygofers; pygofers with the side margins compressed below, an oblique black mark just back of the margin beneath. Described from numerous specimens collected at Ames, Iowa.

Readily separated from *comma* by the additional fork of the first sector, the spots on the disk of the vertex and the number of stripes on the elytra. Superficially it so closely resembles that species that hitherto specimens have been confused with those of that species.

Larvæ very broad, stout forms; head large, resembling the adult; vertex slightly more pointed; color creamy white, with four brown stripes as follows: An inner parallel pair arising from distinct spots on the apical margin of the vertex and extending to the tip of the abdomen on either side, a pair just inside the margin of the body arising behind the eyes and terminating before the last abdominal segment.

Larvæ were taken from *Stipa spartea* June 4th, and issued in the cages on the 6th. They were found up to June 10th, when they had all issued. Adults were taken through June and late into July, but no second brood appeared, probably owing to the ground having been mowed over June 27th, thus destroying the eggs.

This species was never taken away from *Stipa*, but occurred in such abundance that it over-ran the adjacent grasses.

ATHYSANUS MAGNUS N. SP.

(Pl. xxvi, Fig. 2.)

Form similar to *Athysanus argentatus* Fab., but still larger. The largest species in the genus. Ashy, with transverse light bands on head and pronotum. Length of female, 8 to 9 mm; width of eyes, 2.50 to 3 mm.; male smaller.

Head wider than the pronotum, short, scarcely exceeding half its length; anterior and posterior margins nearly parallel; ocelli distant from eyes; vertex four times wider than long; front four times as wide at ocelli as on clypeus, widest at antennæ; antennæ small, short, inserted under a small ledge; clypeus spatulate; genæ broad; pronotum nearly three times wider than long; elytra strong, broadest at base, without an appendix, two ante-apical cells nearly equal in size, four terminal cells and one costal cell.

Color: Vertex light yellow with an arcuated line between the ocelli; face finely irrorate with brown, becoming darker below; antennal pit black; pronotum fuscous, margins darker, a broad light yellow transverse band just before the posterior margin; elytra, nervures brown, margined with light, disk of the cells finely irrorate with fuscous, costal margin broadly cream colored; tergum with a dark median stripe; venter brownish; femora mottled with brown; tibiæ black lined.

Genitalia: Ultimate ventral segment of female slightly longer than penultimate, strongly notched in middle, broadly, rather acutely lobed either side, lateral angles rounding, slightly exceeding median lobes; male valve small, triangular, one-half the length and two-thirds the width of the ultimate segment; plates together long triangular, about one-half longer than breadth at base, margins thickened and fringed with stout hairs. Described from twenty specimens.

It has been received from Texas, Kansas, Nebraska, Dakota, and northwest Iowa, also collected sparingly at Ames, from *Spartina cynosuroides* exclusively.

CHLOROTETTIX SPATULATA N. SP.

(Plate xxvi, Fig. 4)

Intermediate, in form and size between *unicolor* and *galbanata* but more distinctly green than in either species. Length, 7 mm; width, 1.75 mm.

Vertex two and one-half times wider than long, margins parallel or slightly longer on middle than next eye, anterior margin broadly rounding

to the face; front narrowing rapidly to the small clypeus; genæ broad, rounding below; pronotum one-half longer than vertex, emarginate behind; side margins short, not strongly carinated; elytra broader than in *Iusoria*, venation similar, weak.

Color: Green; elytra sub-hyaline sometimes pallid.

Genitalia: ultimate ventral segment of female very long on lateral margin, posterior margin produced, broadly notched, more than one-half the depth of the segment, apex of notch with a spatulate process two and one-half times as long as breadth at base, two-thirds the length of the notch, lateral margin of segment rounding to the acute lateral angles. Male valve appearing as a narrow margin to the ultimate segment; plates sloping, broad at base, convexly rounding, acutely pointed, about equaling the pygofers.

Described from forty-two examples collected at Ames, Iowa. It has also been received from Colorado (Gillette) and Nebraska (Bruner).

THAMNOTETTIX LUSORIA N. SP.

Form and general appearance of *Chlorotettix tergatus*, but with a sharper vertex and more general reddish cast. Length, 7 to 8 mm; width, 2 mm.

Vertex slightly convex, one-half longer on middle than next eye, twice wider than long, margins broadly rounded, but with a distinct, slightly produced tip; front one-third longer than wide, three times wider at ocelli than on clypeus; pronotum long, front margin strongly rounding, posterior margin nearly truncate, sides long, carinated; scutellum with a quadrate light area on the disk, including two dark spots; elytra two and one-half times longer than wide, much exceeding the abdomen, without an appendix, first anteapical long, parallel margined.

Color: Similar to *Chlorotettix necopina*; vertex olive brown with a faint crescentiform band before the eyes; pronotum fulvous brown; elytra sub-hyaline with a distinct reddish tinge, nervures light; below tawny yellowish.

Genitalia: Ultimate ventral segment of female long, slightly emarginate behind, with a strong, angularly pointed, dark margined median tooth about equaling the acutely rounding lateral angles; pygofers long and narrow, nearly half the length of the abdomen; male valve very short and broad, less than half the length of the ultimate segment; plates strong, flat, one-half longer than breadth at base, outer margins thickened, sparsely hairy, points strongly divergent, usually a fuscous line on either side arising from a spot at the base.

Described from eight males and ten females all collected at Ames, Iowa.

THAMNOTETTIX LONGULA G. AND B.

Hemiptera of Colorado, p. 97.

Form of *Iusoria* but much smaller; coloration similar to *T. tenuis* Germar. Length, 5 to 6 mm; width, 1.40 mm.

Vertex twice wider than long, slightly longer on middle than at eye, margin rounding, tip slightly produced, front twice wider at ocelli than on clypeus, base of suture rounding; clypeus broadest at the tip; pronotum one-half longer than vertex, slightly concave behind lateral margins, short, rounding; elytra as in *Iusoria*, central anteapical cell constricted.

Color: Fulvous maculate with dark chestnut, vertex light fulvous, ocelli white, connected by a light line which runs forward on the tip; a round spot on either side at the base of vertex and a median line, extending forward to the white transverse line, chestnut; front fulvous with dark sutures and abbreviated arcs along the lateral margins dark chestnut; remainder of the face pale yellow with dark figure; pronotum fulvous with the anterior margin maculate with chestnut and bright yellow; scutellum fulvous with a quadrate light-yellow area on disk containing two round chestnut spots; elytral nervures light, chestnut-margined.

Genitalia: Ultimate ventral segment of female twice wider than long, posterior margin slightly notched, much depressed in the middle, giving it the appearance of being angularly excavated; pygofers very narrow, long, strongly spined; male valve broad, about equaling the ultimate segment in length; plates broad at base, convexly rounding, with stout spines to the nearly parallel margined attenuate, unarmed tips.

Described from two males and three females. Collected at Ames, Iowa. One specimen received from Douglass county, Kan. (Kellogg).

[NOTE—Since writing this as the description of a new species, an examination of the Gillette and Baker type has enabled us to refer our specimens to their species. As their description was from male alone, we have thought best to allow our description, which covers both sexes, to stand as sent to printer.]

THAMNOTETTIX PERSPICILLATA N. SP.

Form of *longula* nearly, but much smaller; elytra hyaline with numerous black spots; length, 3.50 to 4 mm.; width, .9 mm.

Vertex scarcely wider at base than long, little longer at middle than on eye, evenly rounding to front: front inflated, long, roundly narrowing to the small clypeus; clypeus broadening at apex; genæ distinctly angled, nearly straight margined below; pronotum slightly longer than vertex, lateral margins obsolete, posterior angles approaching right angles; elytral venation strong, similar to *longula*, appendix distinct.

Color: Pearl gray; ocelli large, white; vertex light cream color, washed with orange; two approximate oblique dashes on the tip, continuing as lines to the ocelli, and a round spot just behind either ocellus, black; a double median light brown line deflected to either side, just before the middle, forming two chestnut crescents on the disk; basal half of the disk on either side, with a large fulvous ring, enclosing a white spot; pronotum gray, with six white-margined, black spots, arranged in pairs on the anterior margin; scutellum pale yellow, with about five black spots; elytra milky, sub-hyaline, with a fulvous iridescence; nine black spots on each elytron, as follows: Three equidistant small spots on the sutural margin, a spot on the

base of clavus, one on the claval suture one-third the distance from the base to apex, a spot on each of the two apical veinlets, a large spot on the disk of corium between the first and second sectors, and another large one on the sutural margin before the median small dot; front gray, with a median white line, and white arcs, the upper pair forming an arch above the rest, nearly transverse; rest of face light, a black spot under each ocellus and one on either side of the antennal base; tergum light yellow, disk clouded with dark, a row of black spots on either margin; connexivum and venter each with a row of spots next the suture; legs maculate.

Genitalia: Ultimate ventral segment of the female one-half longer on lateral margin than penultimate, posterior margin angularly produced. one-third the length of segment; male valve broad and short; plates broad at base, narrowing rapidly to beyond the middle, with produced attenuate points, one-half longer than width at base, margin stout, fringed with long curved hairs, an oblique black mark on either side at base.

Described from two females and four males, Ames, Iowa.

PHLEPSIUS ALTUS N. SP.

(Plate xxvi, Fig. 5.)

Form similar to *superbus*, short and stout, elytra somewhat flaring: head short and broad, similar to *truncatus*. Dark fulvous brown; length, 5.50 mm; width, 2 mm.

Head slightly wider than the pronotum; vertex scarcely one-third longer at middle than next eye, three times wider than long, less than one-half the length of the pronotum, rounding to the front with a faint carina, as in *cinereus*; front three times wider above than on clypeus, twice longer than wide, slightly expanded below; loræ large, nearly twice wider than clypeus pronotum two and one-half times wider than long, lateral margins very short, less than one-half the length of the vertex, posterior angle well marked; elytra broad, about twice longer than wide, without an appendix, veins on clavus but slightly approaching each other in the middle, seldom with a cross nervure central apical cell no longer than breadth on margin.

Color: Dark fulvous; pronotum and scutellum soiled yellowish-white; irrorate with fulvous brown, disk of pronotum usually clouded with fuscous; vertex and face yellow, finely irrorate, almost clouded with fulvous, usually without pattern of marking except the white margined ocelli and a white spot on the upper angle of the loræ; elytra pearly white, washed with yellowish and irrorate with dark fulvous, except for numerous spots, venter yellowish-brown; legs brown with dark markings.

Genitalia: Ultimate ventral segment of female longer than penultimate; middle half of posterior margin truncate, with a deep median slit and a minute lobate indenture on either side; lateral half of either side produced as a semi-circular lobe against the side of the pygofer; male valve large, longer than ultimate segment, broadly lobate, margin indented on either side of the apex; plate broader than the valve, rapidly, convexly narrowing to the middle, then slightly produced, roundly pointed; ventral surface convex, disk apparently raised, lighter. Described from sixty specimens.

This species has been collected at Ames and Little Rock, Iowa, and specimens are at hand from West Point, Neb.

(Bruner). It belongs to the group of Phlepsids with the head as broad as the pronotum, but may be readily separated from all the other species of the group by its stouter form and flaring elytra, as well as by the genitalia.

PHLEPSIUS MAJESTUS N. SP.

(Plate xxvi, Fig. 6.)

Form of *spatulatus*, nearly, but larger, with much longer elytra; color distinctly reddish brown with copper reflections; length, 9 to 10 mm.; width on costa, 3 to 3.50 mm.

Head much narrower than the pronotum; vertex, flat, twice wider than long, one-fourth longer on middle than next to eye; front much narrower than in *spatulatus*, very nearly twice longer than wide, basal suture obsolete; clypeus broadly spatulate, twice wider at apex than on middle of loræ; pronotum fully twice longer than vertex, anterior margin strongly produced, lateral margin as long as the vertex, carinate, strongly oblique; elytra long and narrow, much exceeding the abdomen, veins on clavus converging, united by a cross nervure, apical veinlets curved, central apical cell one-half longer than breadth at apex; a number of extra veinlets from the first anteapical cell to the costal margin, reticulations very strong, appearing almost as nervures; closely mimicing the appearance of *Gypona octo-lineata* in this respect.

Color: Cuprescent; vertex light yellow, with two approximate dots near its tip; a broad black band between anterior half of eyes, straight-margined in front, excavated either side of the middle, behind, and often interrupted medially with brown, and a spot on either side of base near eye brow; face pale yellowish, sutures and about nine abbreviated arcs fuscous; pronotum fulvous with lateral margins, a Y-shaped mark behind either eye and numerous minute maculations on the disk, creamy white; scutellum fulvous yellow, disk with two brown spots, margin with alternate dark and light markings; elytra yellowish white, nervures and coarser irrorations, fulvous brown; tergum and venter yellowish, dark on the disk; legs yellow; anterior coxæ with large brown spots; femora and hind tibiæ with a series of minute, black dots.

Genitalia: Ultimate ventral segment of the female broader than in *spatulatus*, lateral margins nearly straight, angles rounding, posterior margins roundly emarginate either side of two large, divergent, acute points, which extend beyond the lateral angles, and are separated by a broad deep notch extending over half way to the base; male valve roundly produced apex broad, nearly equaling the ultimate segment in length; plates rather narrow, elongate, three times the length of the ultimate segment. Described from five females and four males.

Two females of this species were included by Mr. Van Duzee in his description of *spatulatus* remarking, however, that they were larger and fulvous brown in color and might easily be mistaken for *Gyponas*. A larger series of both species show them to be decidedly distinct. *Spatulatus* is much

smaller, nearly cinereous in color and has much finer irrorations on the elytra. Specimens are at hand only from Texas, Arizona and California, indicating a southwestern distribution; *majestus* is much larger, fulvous red with coppery reflections, being the largest and most highly colored species of the genus. It closely mimics *Gypona scarlatina* in size and appearance, and occurs in similar situations. Specimens have been collected at Ames, and one specimen received from Philadelphia and another from Mississippi. None have been received from the known habitat of *spatulatus* and it would seem to be an eastern form although its scarcity in collections may be due to the fact that it is extremely difficult to catch.

PHLEPSIUS DECORUS N. SP.

(Plate xxvi, Fig. 7.)

Form very broad and short; elytra flaring; color milk-white, sparsely irrorated with deep fuscous or black giving it a dark, maculate appearance with scarcely a trace of fulvous. Length, 6 mm; width, on center of costa, 2.50 to 3 mm.

Head narrower than the pronotum; vertex flat, similar to *majestus*, twice wider than long, slightly longer on middle than next eye, acutely angled with the front; front broad, flat, sides straight, twice wider above than at apex, about one-third longer than wide, basal suture well marked; genæ broad, outer angle distinct; pronotum short, about half longer than the vertex; lateral margin oblique, carinate, two-thirds the length of the vertex, posterior angle well marked; elytra short, scarcely twice longer than wide, veins on clavus nearly touching in the middle, united by a short cross nervure, central apical cell half longer than wide.

Color: Vertex pearly white with numerous fuscous irrorations which merge into an irregular transverse band between the eyes; face creamy white, irrorate with fuscous, the arcs nearly obliterated; clypeus fuscous on suture, two slightly divergent lines on disk; pronotum yellowish with fine fuscous irrorations, two crescentiform dashes near the anterior margin, black; scutellum soiled yellowish, two fuscous spots on the disk; elytra milk-white, nervures black, claval suture and margins of the nervures yellowish brown, irrorations fuscous to black, more or less definitely arranged in three transverse bands and a series of spots on the costal margin toward the apex; scutellar and sutural margins broadly white.

Genitalia: Ultimate ventral segment of female very broad and short, over four times wider than long, nearly truncate behind with a broad deep notch, extending half way to the base. Male: valve small triangular; plates broad, short and convex, scarcely half longer than ultimate segment, parallel margined at base, bluntly angularly pointed.

Described from one male from Lincoln, Neb. (Bruner), and one female collected at Ames, Iowa.

This and the preceding species belong to the section of the genus in which the head is narrower than the pronotum and which

includes *spatulatus*, *ovatus*, *excultus*, *superbus* and *neomexicanus*. They may be readily separated from the other members of the group by their more definite colors as well as by their distinct genitalia.

ADDITIONS TO THE FORMER LISTS OF IOWA SPECIES.

The following list embraces the additions, not included in the preceding notes, that have been made to the Iowa fauna during the past year or two.

HETEROPTERA.

Perillus exaptus Say. This handsome species has been taken at Little Rock, Lyon county, and Ames.

Podisus serieventris Uhl. Ames.

Oebalus pugnax Fab. This peculiar southern form was taken at Ames in some numbers the past summer.

Lioderma belfragii Stal. A single specimen of this species has been taken by Mr. Ball at Little Rock, Lyon county.

Alydus conspersus Montandon. This name should replace that of *Alydus ater* in previous list.

Neides muticus Uhl. Ames, Iowa.

Belonochilus numenius Say. Ames; not common.

Ilnacora divisa Reut. Ames.

Phytocoris colon Say. Ames.

Coriscus punctipes Reut. Ames; common.

Coriscus inscriptus Kby. Ames.

Pygolampis sericea Stal. Ames; rare.

Barce annulipes Stal. Iowa City and Ames.

Ranatra quadridentata Stal. Common; *fusca* is less common if, indeed, it occurs in the state.

HOMOPTERA.

Ulopa canadensis Van D. Ames; rare.

Bythoscopus distinctus Van D. Common on Hackberry at Ames.

Idiocerus cratagi Van D. Ames.

Agallia novella Say. Ames.

Pachyopsis robustus Uhl. Not common.

Oncometopia limbata Say. Little Rock and Hampton.

Tettigonia similis Woodworth. Common at Ames.

Diedrocephala angulifera Walk. Ames and LeClaire.

Gypona scarlatina Fitch. Ames.

Gypona albimarginata Woodworth. Ames.

- Strongylocephalus agrestis* Fall. Ames; rare.
Paramesus vitellinus Fitch. Ames.
Athysanus extrusus Van D. Ames.
Doratura argenteola Uhl.
Doratura minuta Van D. Ames.
Athysanus plutonius Van D. Ames.
Athysanus gammaroides Van D. Ames; not common.
Athysanus striatulus Fall. Ames.
Eutettix lurida Van D. Ames.
Eutettix southwicki Van D. Ames.
Eutettix johnsoni Van D. Ames; rare.
Phlepsius humidus Van D. Ames.
Phlepsius incisus Van D. Ames.
Phlepsius truncatus Van D. Ames.
Phlepsius cinereus Van D. Ames. Fairly common in 1896, but probably a southern form.
Phlepsius fuscipennis Van D. Ames; not common.
Scaphoideus intricatus Uhl. Ames; rare.
Scaphoideus luteolus Van D. Ames.
Scaphoideus lobatus Van D. Ames.
Scaphoideus scalaris Van D. Ames. Hitherto credited only to California.
Scaphoideus auronitens Prov. Ames.
Thamnotettix inornata Van D. Ames. Hitherto recorded for New York only.
Thamnotettix longiseta Van D. Ames. Originally described from Colorado.
Thamnotettix smithi Van D. Ames. Hitherto recorded only from New Jersey.
Thamnotettix fitchi Van D. Ames.
Chlorotettix galbanata Van D. Ames; common.
Gnathodes abdominalis Van D. Ames.
Gnathodes impictus Van D. Ames.
Cicadula variata Fall. Ames.
Cicadula punctifrons Fall. Ames.
Kybos smaragdula Fall. Ames.
Dicraneura abnormis Walsh. Ames.
Dicraneura flavipennis Fab. Ames; common.
Empoasca obtusa Walsh. Ames.
Olistoptera xanthocephala Germ. Ames.
Monecphora bicincta Say. Ames.

Stenocranus croceus Van D. Ames.

Liburnia vittatifrons Uhl. Not common except in particular locations.

Scolops grossus Uhl. Common in 1896.

Vanduzee arcuata Godg. Occurs on locust and usually very abundant where found, Ames and Albia.

Telamona godingi Van D. Ames. Not common.

Stictocephala lutea Walk. Common. Confused with *inermis*.

Publilia modesta Uhl.

Diaspis rosae. Muscatine. Very abundant and destructive to roses and other garden shrubs. A serious pest where it occurs.

Hæmatopinus pedalis Osb. An interesting parasite of sheep, occurring on the feet and lower part of legs, but not on wooly parts of the body.

Euhæmatopinus abnormis Osb. A very peculiar parasite of the common mole *Scalops argentatus*. The femora of the hind legs bear disk-like processes which evidently oppose the tibiæ of the middle legs as a clasping organ. I have described it in a bulletin on "The Insects Affecting Domestic Animals," recently issued by the Div. Ent. U. S. Dep. Agriculture.

EXPLANATION OF PLATES.*

PLATE XIX.

Fig. 1. *Xerophloea viridis* Fab. a, female, dorsal view; b, face; c, lateral view; d, larva; e, male; f, female, genitalia.

Fig. 2. *Xestcephalus coronatus* n. sp. female, dorsal view.

Fig. 3. *Euacanthus acuminatus* Fab. a, female; b, larva, dorsal views.

PLATE XX.

Fig. 1. *Dorycephalus platyrhynchus* Osb. a, female; b, male, dorsal view; c, face; d, female, e, male genitalia; f, eggs in grass stem; g, eggs enlarged; h, eggs with larva nearly ready to hatch; i, newly hatched larva; j, larva after first moult; k, after second moult; l, pupa.

Fig. 2. *Hecalus lineatus* Uhl. a, female; b, male, c, larva, dorsal view; d, face; e, female, f, male genitalia.

PLATE XXI.

Fig. 1. *Parablocratrus viridis* Uhl. a, male; b, female; c, mature larva, dorsal views; d, female; e, male genitalia; f, eggs in grass stem; g, eggs enlarged; h, single egg much enlarged, showing young; i, larva newly hatched; j, after first moult.

Fig. 2. *Athysanus obtutus* Van D. a, ventral; b, lateral; c, dorsal view of female; d, female; e, male, genitalia; f, pupa; g, eggs much enlarged; h, eggs in place under grass leaf sheath.

PLATE XXII.

Fig. 1. *Deltocephalus reflexus* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female; e, male, genitalia; f, wing; g, larva; h, face of larva.

* All figures here given are photo-reproductions of drawings made by Miss Charlotte M. King, under the personal direction and supervision of the authors.

In plates xxii to xxv four species are shown on each plate, each one occupying one-fourth of the plate, and being lettered independently, and in nearly every case the letters correspond for each species, notice of which will avoid any possible confusion in reference to figures.

Fig. 2. *D. inflatus* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female; e, male, genitalia; f, wing; g, abdomen of male, lateral view.

Fig. 3. *D. pectinatus* a, dorsal view; b, face; c, vertex and pronotum; d, male, e, female, genitalia; f, wing; g, larva.

Fig. 4. *D. abbreviatus* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

PLATE XXIII.

Fig. 1. *D. albidus* n. sp. a, dorsal view; b, face; c, vertex; d, female, e, male, genitalia; f, wing; g, larva.

Fig. 2. *D. sayi* Fh. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

Fig. 3. *D. configuratus* Uh. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

Fig. 4. *D. oculatus* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

PLATE XXIV.

Fig. 1. *D. melscheimeri* Fh. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

Fig. 2. *D. debilis* Uh. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, lateral view of head.

Fig. 3. *D. inimicus* Say. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

Fig. 4. *D. minimus* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing; g, larva.

PLATE XXV.

Fig. 1. *D. signatifrons* Van D. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing.

Fig. 2. *D. weedi* Van D. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing.

Fig. 3. *D. compactus* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male genitalia; f, wing.

Fig. 4. *D. sylvestris* n. sp. a, dorsal view; b, face; c, vertex and pronotum; d, female, e, male, genitalia; f, wing.

PLATE XXVI.

Fig. 1. *Platymetopius cinereus* n. sp. dorsal view 1a larva.

Fig. 2. *Athysanus magnus* n. sp. dorsal view.

Fig. 3. *Athysanus colon* n. sp. dorsal view 3a wing, 3b larva.

Fig. 4. *Chlorotettix spatulata* n. sp. dorsal view 4a female, ultimate ventral segment.

Fig. 5. *Phlepsius altus* n. sp. female ultimate ventral segment 5a male genitalia.

Fig. 6. *Phlepsius majestus* n. sp. ultimate ventral segment of female, 6a genitalia of male.

Fig. 7. *Phlepsius decorus* n. sp. ultimate ventral segment of female, 7a genitalia of male.

NOTES ON THE ORTHOPTEROUS FAUNA OF IOWA.

BY E. D. BALL.

As a family the Orthoptera have long been regarded as among the most injurious insects of the state. Every addition, therefore, to a list of species adds one more to the number of possible depredators of a given locality. On the other hand, every fact in regard to distribution, life-history or food habits of a species, added to the general knowledge, aids in formulating successful methods of treatment for the particular species.

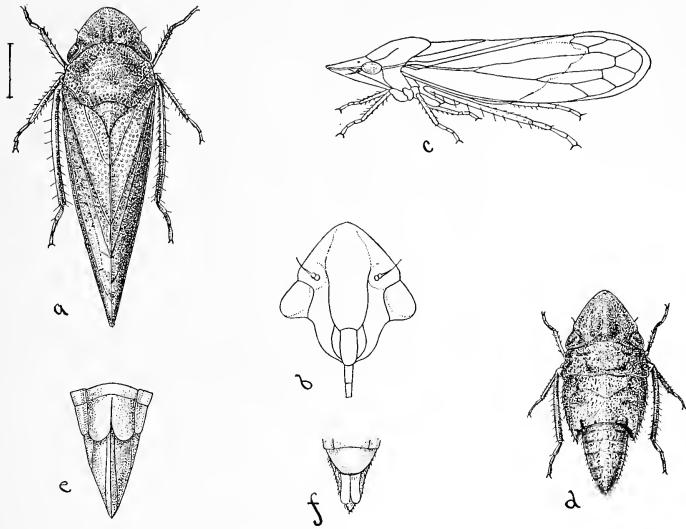


Fig. 1

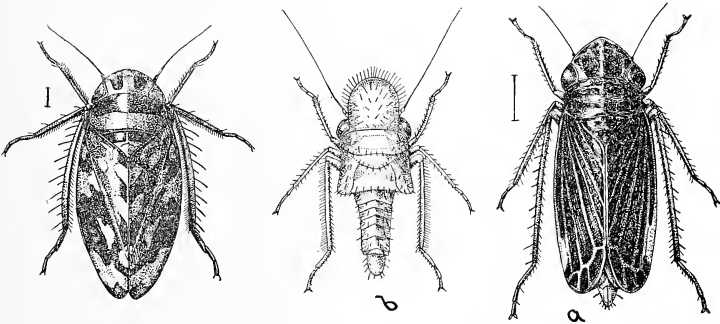
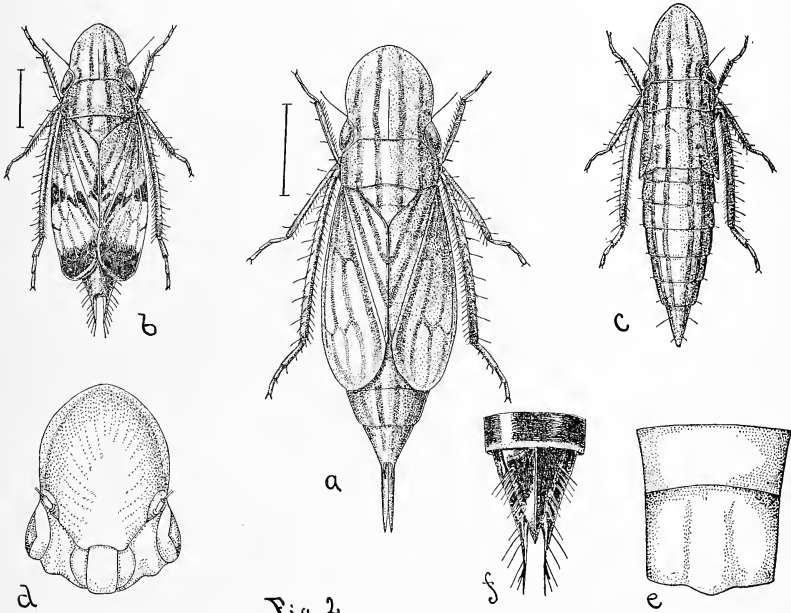
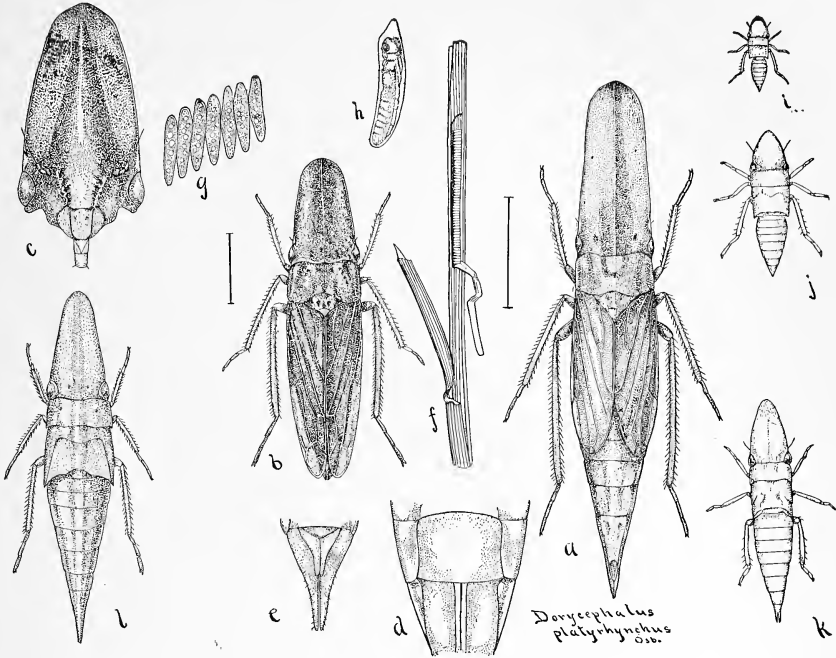


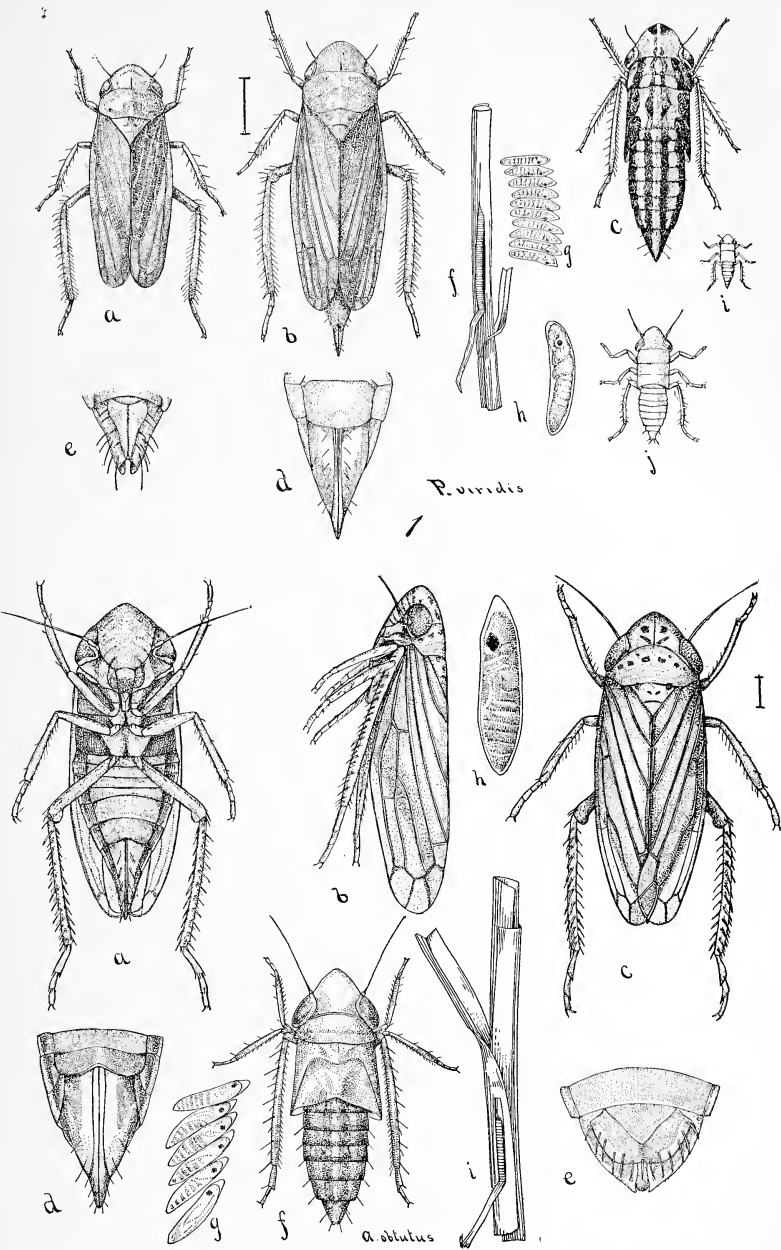
Fig. 2

Fig. 3

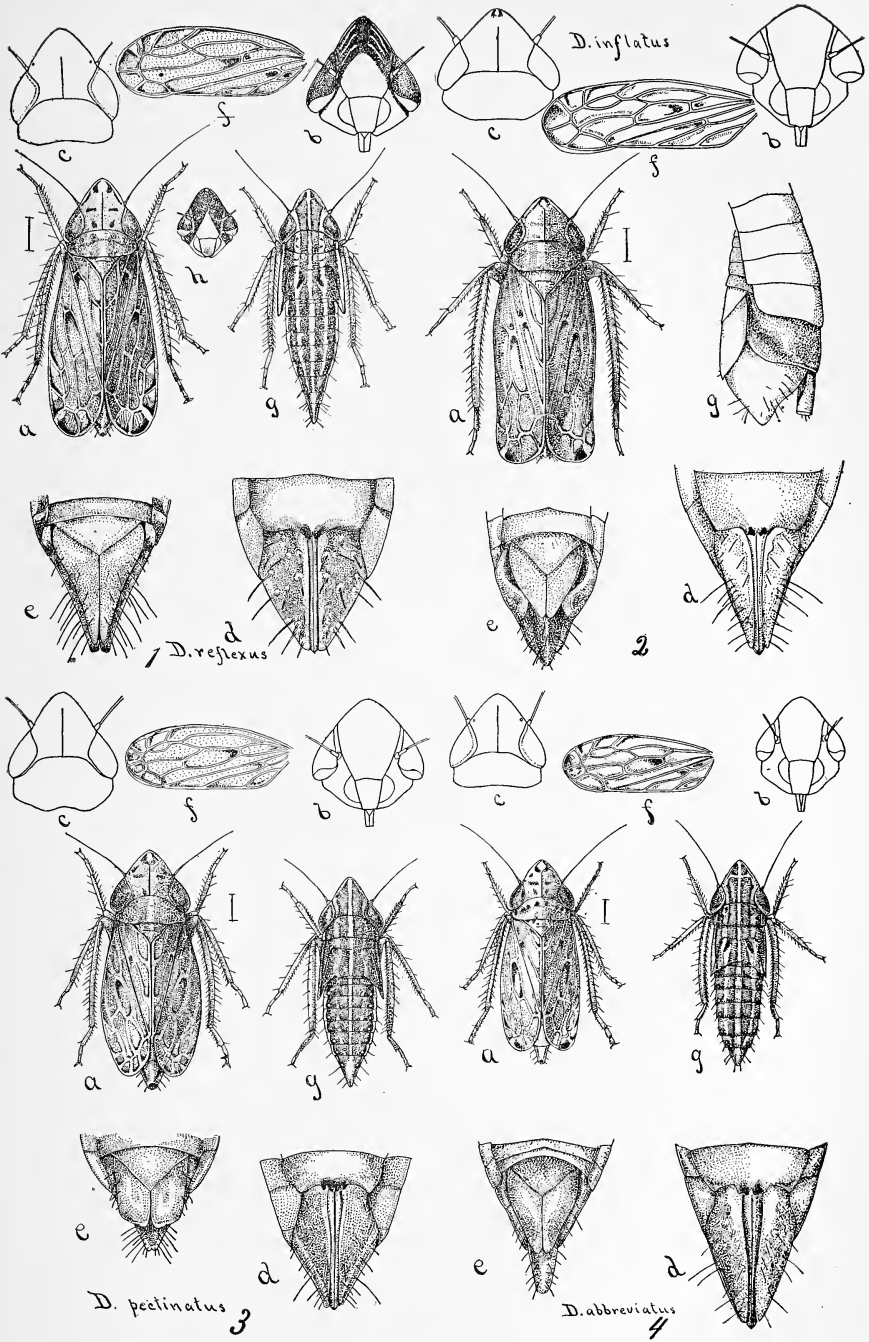
Fig. 1.—*Xerophloea viridis*. Fig. 2.—*Xestocephalus coronatus*. Fig. 3.—*Euacanthus acuminatus*.

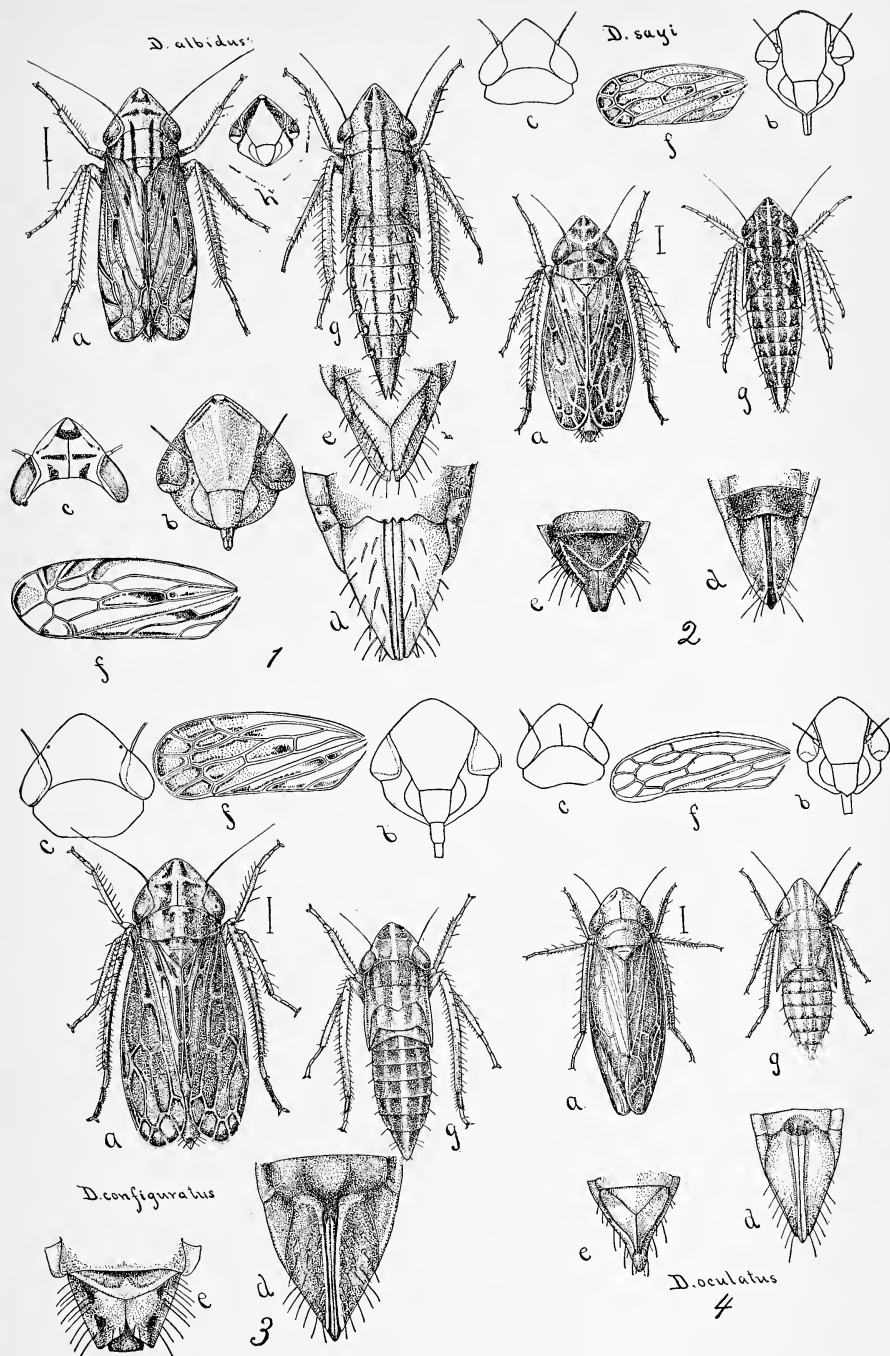


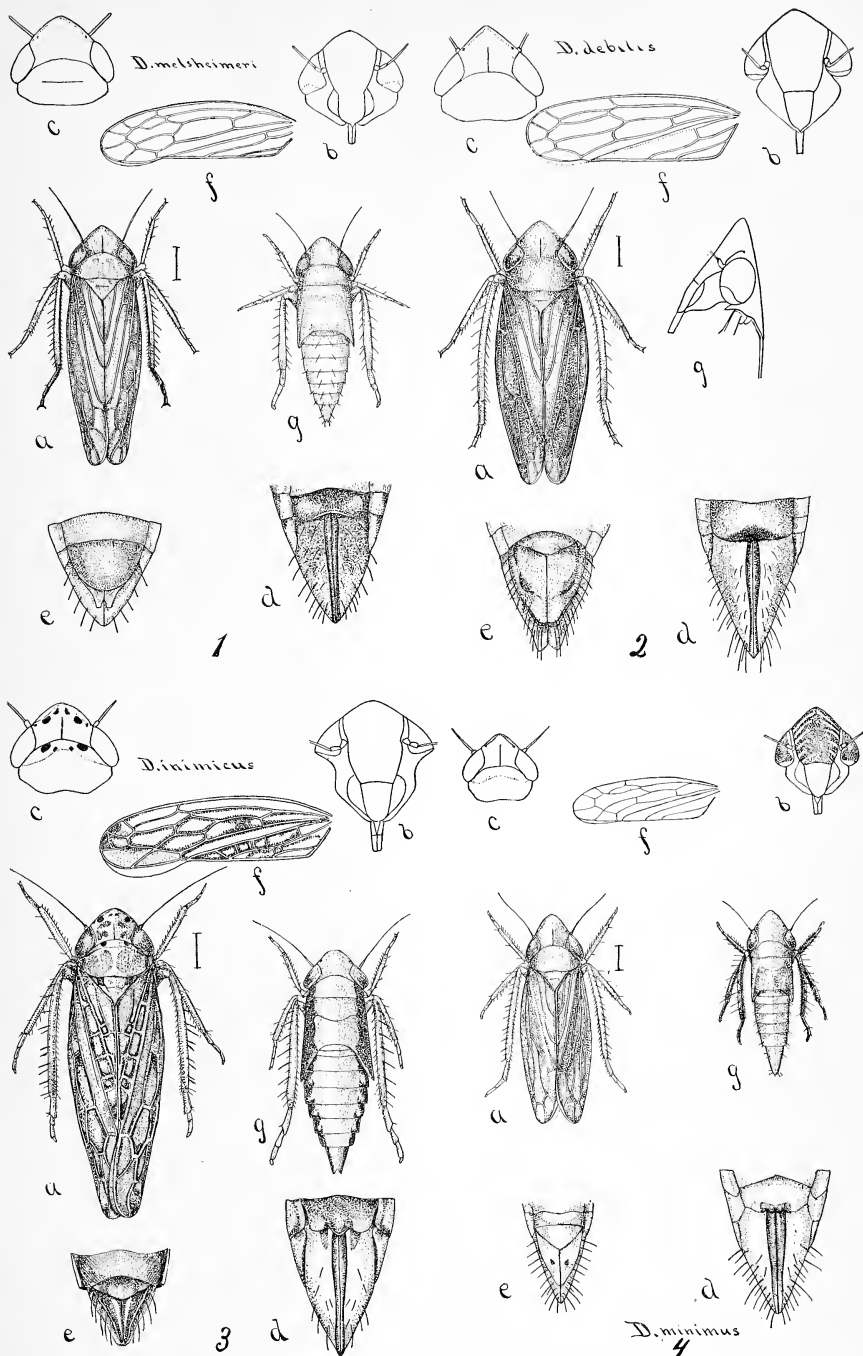












162
3/1/1896

PROCEEDINGS

OF THE

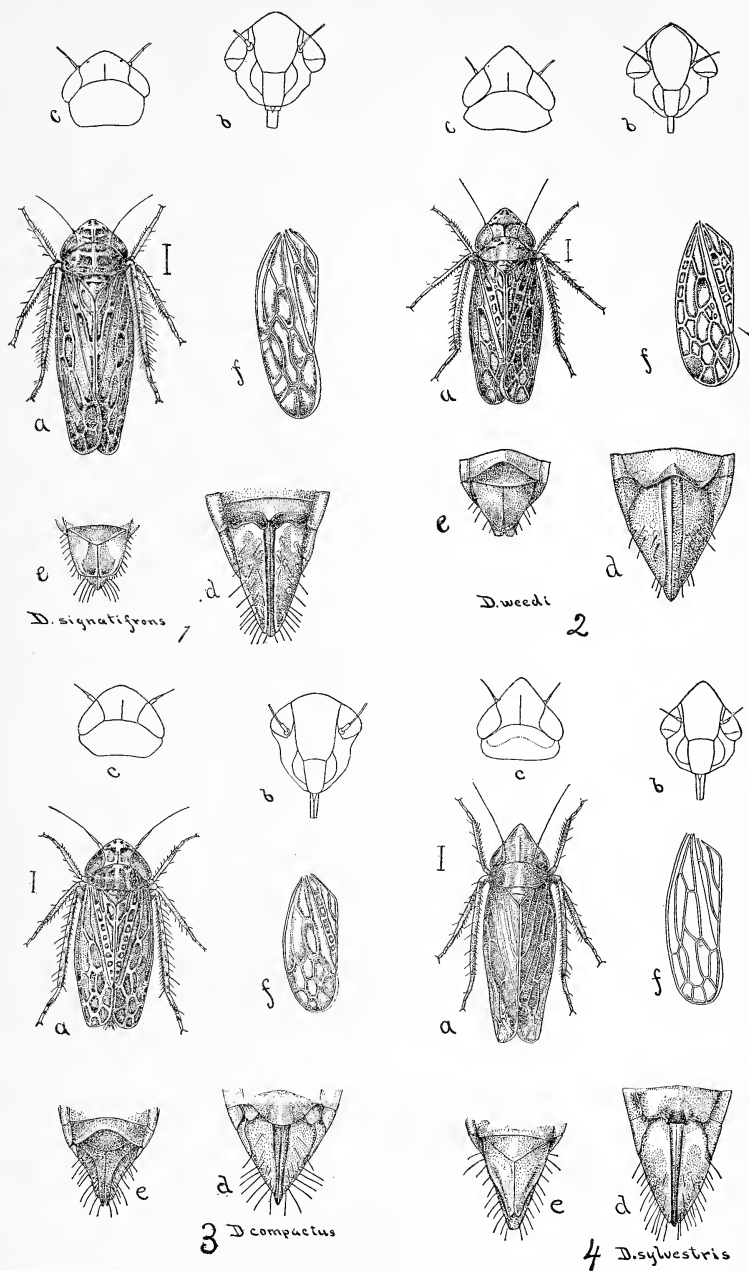
Iowa Academy of Sciences

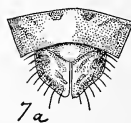
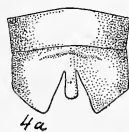
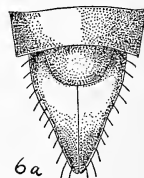
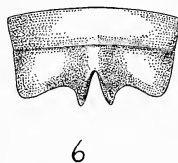
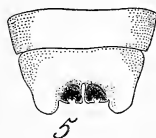
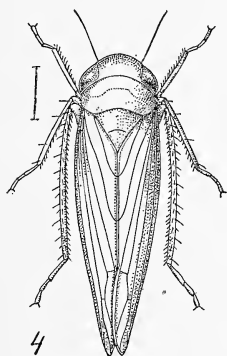
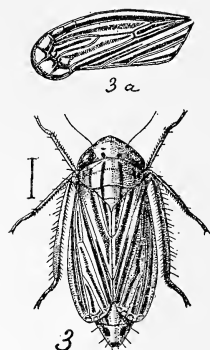
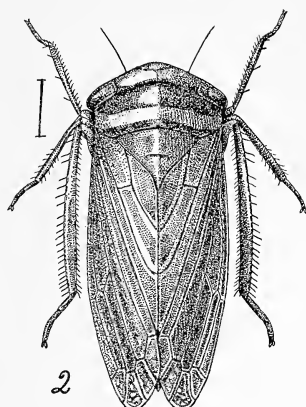
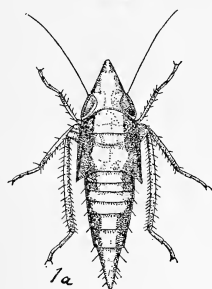
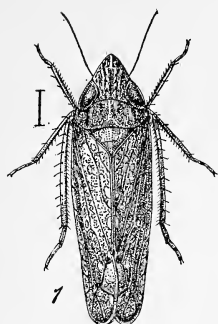
FOR 1895.

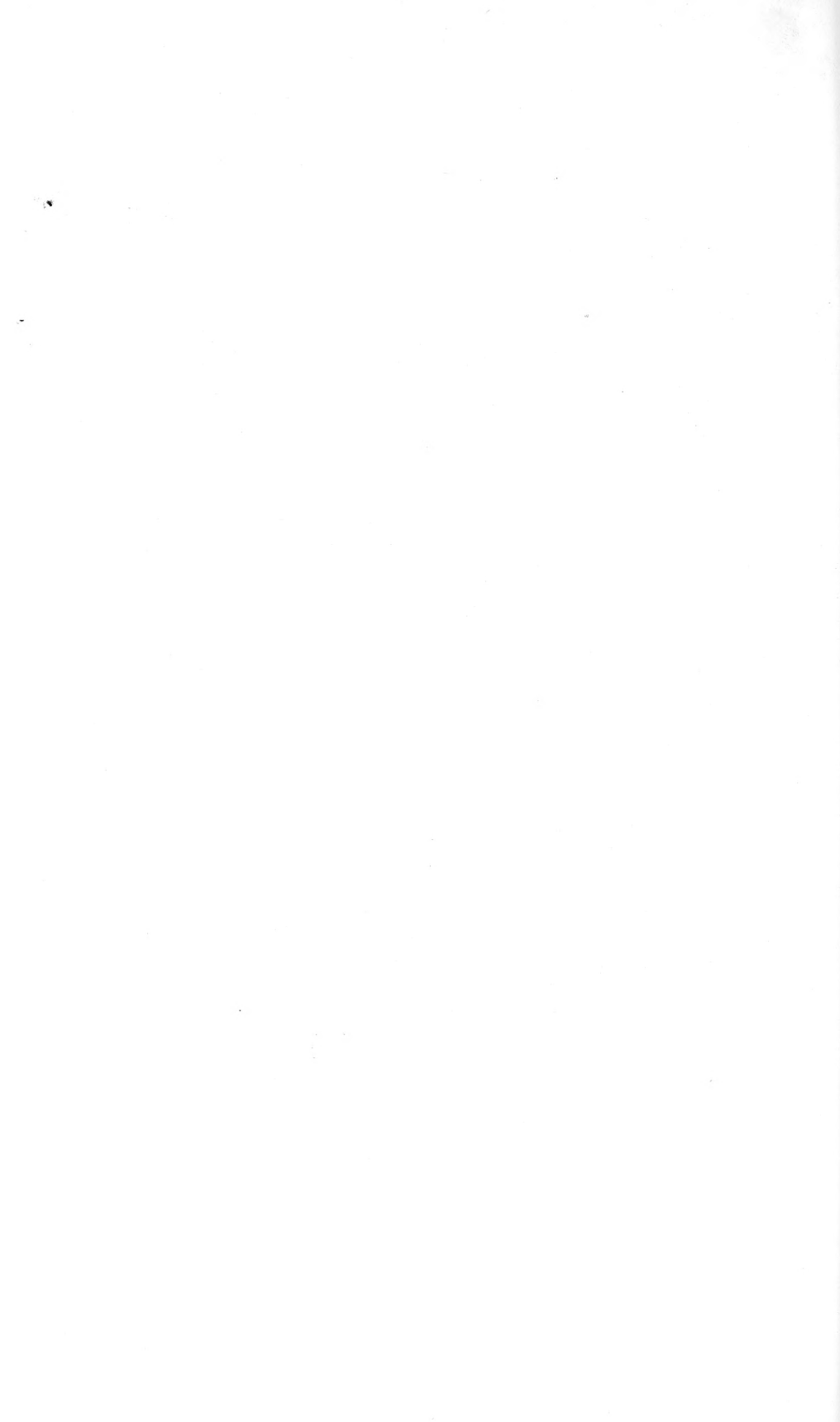
VOLUME III.

PUBLISHED BY THE STATE.

DES MOINES:
F. R. CONAWAY, STATE PRINTER.
1896.







In working over the additional material accumulated, and in rearranging the Orthopterous collection of the Iowa Agricultural college during the early part of the year several additional species were found; these, with some material collected in Lyon and Mahaska counties several years ago, together with the collecting of the present season at Ames, have furnished the basis for an addition of some 30 species to the list published by Professor Osborn in the proceedings of this academy for 1891.

Owing to the fact that there has been considerable revision in nomenclature and synonymy since the publication of the former list, thus rendering necessary a number of changes, and further that a majority of the species would be included in the notes, it has been thought best to make the list of species complete, although in a number of cases nothing additional can be given.

The arrangement of families in the list is purely arbitrary, for as yet there seems to be no satisfactory arrangement based upon philogenetic deductions. Within the families the ordinary arrangement has been adopted except where there has been recently suggested changes. In the groups Tettiginæ and Tryxalinæ, Prof. A. P. Morse's recent revision has been followed and in the Tettiginæ he has kindly verified all the determinations. To Professor Scudder I am indebted for the determination of the Ceuthophilus listed. While to Professor Lawrence Bruner I am under obligations for the determination of a number of species and the verification of the greater portion of the remainder of the list.

ORDER ORTHOPTERA.

Fam. FORFICULIDÆ—Earwigs.

Labia minor Linn, A few specimens taken each year.

Fam. BLATTIDÆ—Cockroaches

Ectobia germanica Steph. Common in stores and houses in towns.

Ischnoptera unicolor Scudd. Occasionally taken at Ames. Specimens were found abundantly in the timber around Oskaloosa in June.

Ischnoptera pennsylvanica DeGeer. Abundant in the timber along the larger streams. Adults during early summer, disappearing by the middle of July.

Periplaneta orientalis Linn. This introduced species, which was formerly confined to a few of the larger cities, has spread

over the entire state and is becoming a veritable nuisance, even in the smaller towns of the prairie region.

Periplaneta americana Linn. Specimens of this large southern form have been found at Carbonado, Grand Junction, Little Rock and Ames, but in every case in buildings where bananas were sold, and it is doubtful if they have gained a permanent foothold.

Fam. PHASMIDÆ—Walking Sticks.

Diapheromera femorata Say. Common throughout the timbered portion of the state. Either this or an allied species has been observed very commonly on the prairies of the north-western portion of the state, during August and September.

Fam. GRYLLIDÆ—Crickets.

Tridactylus apicalis Say. This small species was found rather commonly as nymphs, along the margin of a small stream in August and September, and again the following April. Adults were taken in July.

Gryllotalpa borealis Scudd.

Gryllotalpa columbia Scudd. This and the preceding species are found only in the southern portion of the state. Are they distinct?

Gryllus abbreviatus Serv. The most abundant species in the state occurring everywhere. Sometimes occasions considerable loss in the grain raising sections by cutting the bands of the shocked grain.

Gryllus luctuosus Serv. Rare.

Gryllus pennsylvanicus Burm. A few specimens of a broad headed cricket that has been referred here were taken from the timber in July.

Nemobius fasciatus DeGeer. Occurs with *abbreviatus* in the fields.

Nemobius carolinus Scudd. Common in the woods.

Anaxiphus pulicarius Sauss. A number of these small light colored crickets were taken while sweeping in the woods in July.

Apithes agitator Uhl. One specimen of this southern form has been received from Lee county.

Ecanthus fasciatus Fitch. Abundant everywhere during the latter part of the season.

Ecanthus angustipennis Fitch. Examples of this species appear several weeks earlier than any of *fasciatus*, and may be found rather commonly on the prairie.

Ecanthus niveus Serv. Appears at about the same time as the preceding, but occurs more commonly in the woods.

Ecanthus latipennis Riley. One specimen taken at Ames in September. Probably more common farther south in the state.

Xabea bipunctata DeGeer. Rare.

Fam. LOCUSTIDÆ—Katydids, etc.

Ceuthophilus blatchleyi Scudd. A number found under boards, logs, etc., in July and August.

Ceuthophilus vinculatus Scudd. Common.

Ceuthophilus seclusus Scudd. Rare.

Udeopsylla robusta Hald. Specimens from Little Rock and from the mines of Mahaska county.

Udeopsylla nigra Scudd. Common in holes and cellars.

Pterolepis pachymerus Burm. No specimens have been reported since the former list.

Platyphyllum concavum Say. Rare at Ames.

Amblycorypha oblongifolia Scudd. A few specimens taken each year.

Amblycorypha rotundifolia Scudd. Rather common in the timber, along with the preceding species.

Amblycorypha brachyptera Bruner. Specimens of a much shorter-winged species than either of the above were taken from the prairie of northwestern Iowa some years ago and have been found this season on a few patches of prairie grass at Ames. Professor Bruner has kindly consented to describe it and proposes above name.

Scudderia furculata Bruner.

Scudderia pistillata Bruner. Taken rather commonly from the woods.

Scudderia curvicauda DeGeer. Our most abundant species.

Scudderia furcata Bruner. Common. Smaller than the preceding.

Conocephalus attenuatus Scudd. Common, especially on the prairies.

Conocephalus crepitans Scudd. A single specimen taken at Ames.

Conocephalus ensiger Harr.

Conocephalus nebrascensis Bruner. Fairly common, the brown form is more abundant on the prairies.

Orchelimum nigripes Scudd. Common.

Orchelimum vulgare Harr. Abundant in meadows and low woods where the undergrowth is mainly grasses.

Xiphidium nemorale Scudd. Rather rare.

Xiphidium fasciatum DeGeer. Abundant in meadows everywhere.

Xiphidium attenuatum Scudd. Rare.

Xiphidium brevipenne Scudd. Abundant in low woods and meadows in September and on into October.

Xiphidium nigropleurum Bruner. Rare.

Fam. ACRIDIDÆ—Grasshoppers.

TETTIGINÆ.

Tettix ornatus Say. Abundant in woods and along the margins of the streams.

Tettix arenosus Burm. Common in the timber. More abundant in the early spring than the preceding species.

Tettix granulatus Kirby. This slender form is rather rare.

Paratettix cucullatus Scudd. Adults abundant in the middle of the summer. Larvæ have been taken in the late fall and early spring.

Tettigidea parvipennis Harr. Abundant in low timber land, where the undergrowth is short. The long-winged form, *pennata*, is much more abundant than the other.

TRYXALINÆ.

Pseudopomala brachyptera Scudd. Small larvæ of this species were taken May 12th, and from then until July 3rd, when the last, a full grown female pupa was found. The first adult, a male, was taken June 6th; the first female was taken July 3rd, and the last September 12th. All of these specimens were found on prairie grass principally *Andropogon scoparius*.

Mermiria bivittata Serv. One specimen.

Dicromorpha viridis Scudd. Rather rare. Adult males were taken July 4th and 30th, the females mainly in August.

Eritettix tricarinatus Thos. This species hibernates as nearly full grown larvæ. Adults were first found April 24th and were taken from then until July 4th. Small larvæ were first found the last of August and were abundant throughout the fall until into October. This species was also found on *A. scoparius* and occurred sparingly on the *Bouteloa*s.

Orphula speciosa Scudd. Common from July until September as adults on the prairie grasses. Larvæ have been taken from the first of May until July.

Chloealtis conspersa Harr. Adults were taken this season from June 17th until into September, from a moderately shaded pasture.

Stenebothrus curtipennis Harr. Common; occurs at about the same time and in similar situations with *O. æqualis*.

Mecostithus platypterus Scudd. A single specimen collected at Little Rock, Lyon county. Swept from a meadow.

Mecostithus lineatus Scudd. Scott county. (MacNeil.)

Boopedon nubilum Say. Rare. Two specimens taken in July, 1894.

Eremnus seudderi Bruner. Found in abundance on the top of a sandy knoll August 4th, and from then on until the middle of September. The grass on the knoll consisted almost entirely of *B. hirsuta*.

CEDIPODINÆ.

Chortophaga viridifasciata DeGeer. Adults appear by the 20th of April continuing abundant until the middle of the summer; larvæ appear in August, becoming nearly full grown before winter.

Encoptolophus sordidus Burm. Common on sandy and exposed places throughout the fall.

Arphia xanthoptera Burm. Common in open fields from the middle of August until October.

Arphia carinata Scudd. Common with the preceding.

Arphia conspersa Scudd. Two specimens mentioned in the former list.

Arphia sulphurea Fab. Rather rare. One male was taken May 15th, and another May 23rd.

Hippiscus haldemanni Scudd. Common. Little Rock and Ames.

Hippiscus tuberculatus Pal Beauv. Common in early summer.

Hippiscus variegatus Scudd. Specimens were taken abundantly from the sand knoll from August 20th to September 24th, but were not found anywhere else. Very small larvæ were found with the adults August 20th, so they must have appeared much earlier. The larvæ were about one-third grown by the last of September. The smaller ones had deep red hind tibiæ.

Hippiscus (Xanthippus) zanotectus Sauss. Denison, July 15th; J. A. Allen (Scudder; Psyche 6-392).

Dissosteira carolina Linn. Common.

Spharagemon collare Scudd. Rare.

Spharagemon bolli Scudd. Fairly common along margins of woods and in open places.

Trachyrhachis cincta Thos. Common on sandy places and southern slopes from the middle of July until late in the fall.

Trimerotropis citrina Scudd. Rather rare. Iowa City and Ames.

ACRIDIANÆ.

Brachistola magna Girard. Only found in the western part of the state.

Schistocerca americana Drury. Lee county. Probably occurs throughout the southern part of the state.

Schistocerca alutacea Harr. Isolated individuals have been found from the middle of August on through September.

Schistocerca emarginata Uhl. Common along railway embankments and in hazel brush thickets in August and September. Either a very distinct variety of the above or else another larger species, with bright red or yellow hind tibiæ, and sharply defined black lines under the eyes, was found very commonly in a low marshy place overgrown with willows the last of September.

Hesperotettix pratensis Scudd. Rare. A few examples taken from the sides of the gravel knoll from August 4th to September 3d.

Melanoplus scudderi Uhl. Common in dry open woods in August and September.

Melanoplus occidentalis Bruner. This and the two following species included for the western part of the state on the authority of Professor Bruner.

Melanoplus gracilis Bruner.

Melanoplus albus Dodge.

Melanoplus differentialis Thos. Common about roadways and margins of fields. Adults from August through October. Sometimes quite destructive to corn.

Melanoplus bivitattus Say. Common as adults from July till October.

Melanoplus packardi Scudd. One specimen August 1st.

Melanoplus dawsoni Scudd. High open woods. Adults were taken from June 6th until July 7th, this season.

Melanoplus angustipennis Dodge. Iowa City and Ames. Taken from an open woods and along the margin of an adjoining corn field, from the middle of August until the last of September.

Melanoplus minor Scudd. Rare. A few specimens taken August 11th.

Melanophus punctulatus Scudd. Rare. Des Moines and Ames in September.

Melanophus femur-rubrum DeGeer. Too common.

Melanophus inridus Dodge. This species was taken abundantly from the knolls during July and August.

Melanophus abditum Dodge. This and the following species included on the authority of Professor Bruner.

Melanophus junius Dodge.

Melanophus atlantis Riley. Three specimens of this species were taken September 11th from a high gravel point.

Melanophus spretus Thos. An occasional specimen of this species taken here.

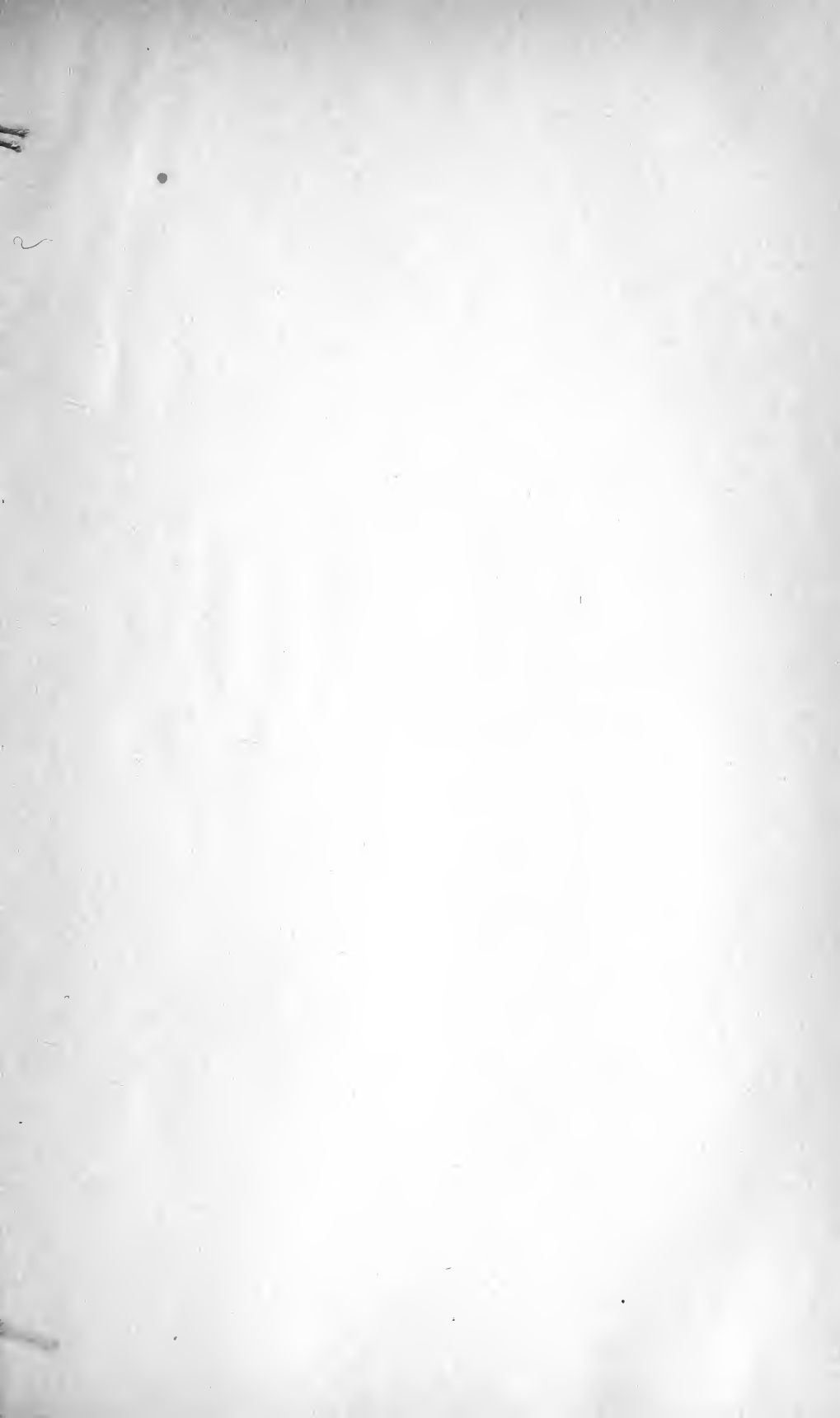
Phoctaloites nebrascensis Thos. Short-winged examples of this unique species fairly common on prairie grass during August and September.

ADDITIONS AND CORRECTIONS.

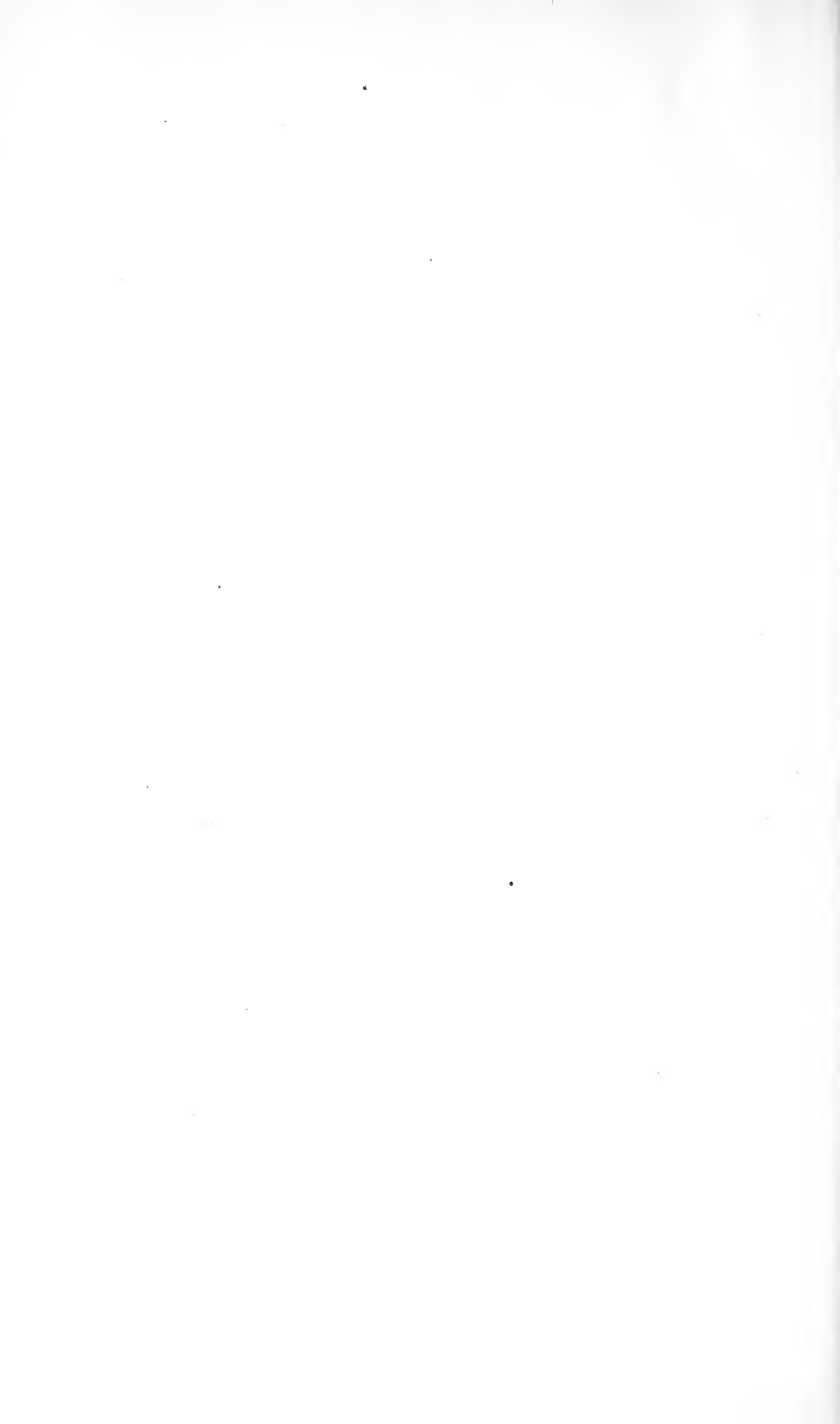
Page	8, under associate members, add Grant E. Finch, West Union.
"	74, line 7, for <i>not common</i> read <i>rather common</i> .
"	75, line 3, for <i>Physia</i> read <i>Physcia</i> .
"	75, line 14, for <i>list</i> read <i>lists</i> .
"	80, line 14, for <i>pussillus</i> read <i>pusillus</i> .
"	84, bottom line, for <i>Lepidum</i> read <i>Lepidium</i> .
"	88, line 22, for <i>Futaceæ</i> read <i>Rutaceæ</i> .
"	88, line 11, for <i>Amphicarpæ</i> read <i>Amphicarpheæ</i> .
"	88, line 20, for <i>Spiræ</i> read <i>Spirææ</i> .
"	89, line 23, for <i>Umaeritiferæ</i> read <i>Lythraceæ</i> .
"	90, line 7, for <i>Cryptocænienia</i> read <i>Cryptotænienia</i> .
"	91, line 16, for <i>Veronia</i> read <i>Vernonia</i> .
"	92, line 2 from bottom, for <i>angustifolia</i> read <i>angustifolia</i> .
"	113, line 10, for <i>leptiota</i> read <i>lepidota</i> .
"	119, line 5, for <i>asper</i> read <i>asper</i> .
"	120, line 20, for <i>sells</i> read <i>cells</i> .
"	121, line 7, for <i>nivilis</i> read <i>mollis</i> .
"	172, line 17, for <i>history</i> read <i>histories</i> .
"	179, line 3, for <i>synonym</i> read <i>synonymy</i> .

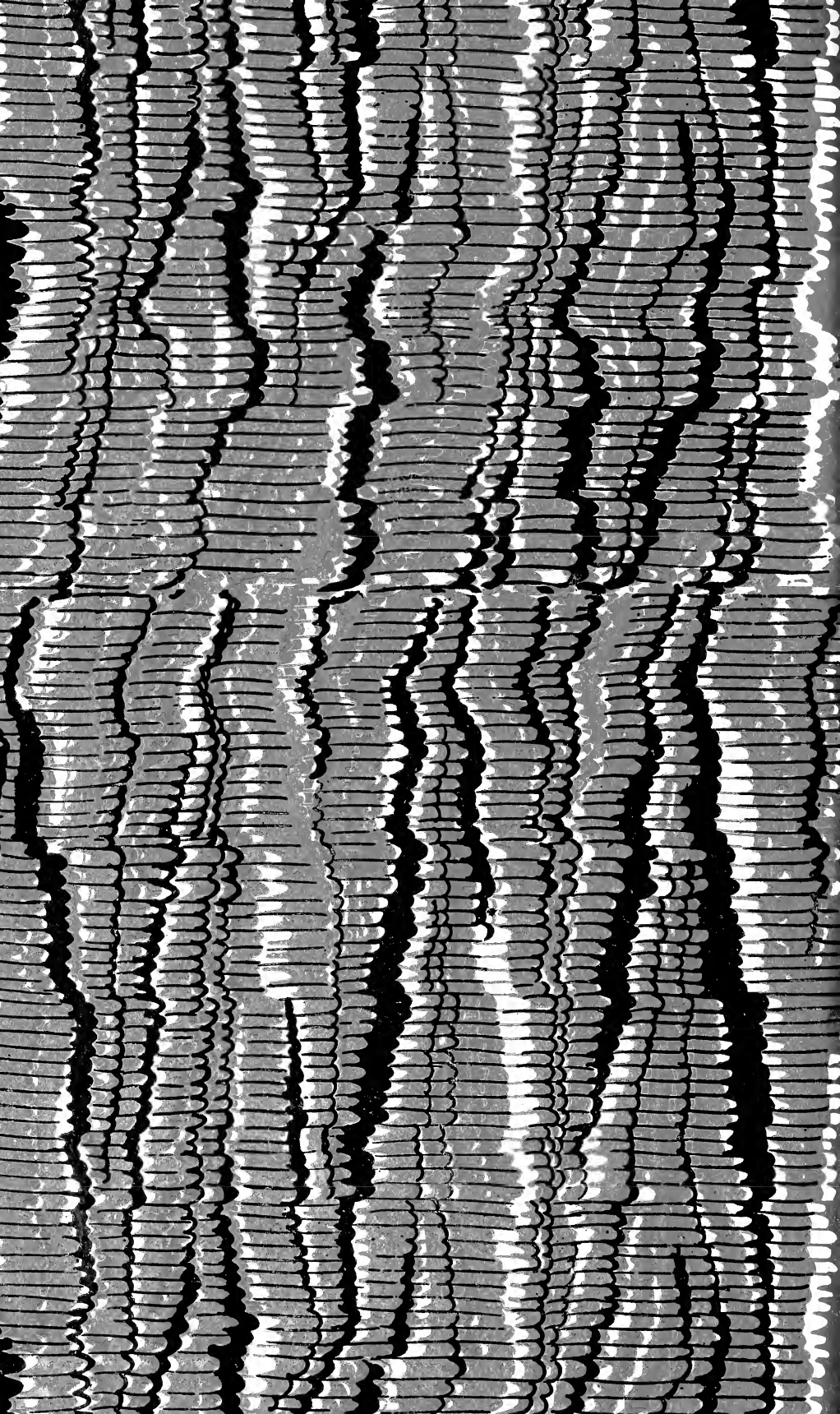
INDEX.

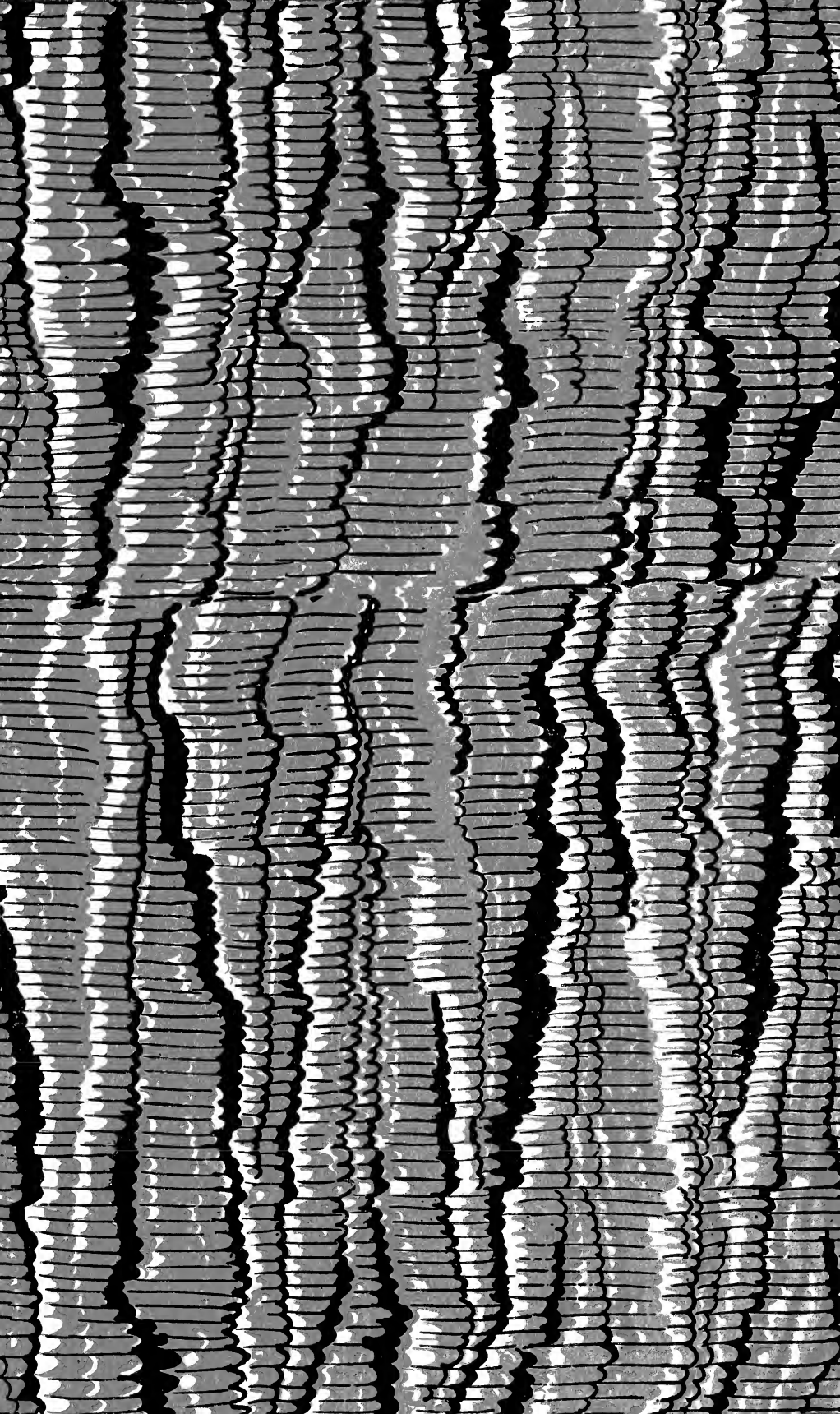
- A** Pre-Kansan peat bed, 63.
Additional observations on the surface deposits in Iowa, 63.
Anatomical study of the leaves of some species of the genus *Andropogon*, 132.
Andropogon, anatomical study of the leaves of, 132.
Anatomical study of the leaves of *Eragrostis*, 138.
Aquatic plants from northern Iowa, notes on, 77.
- Ball, Carleton R.**, article by, 138.
Ball, E. D., article by, 234.
Ball, E. D., and Osborn, H., article by, 172.
Biological station, Illinois, 167.
Brain, nerve cells of the shark's, 151.
Bromus, study of leaves of, 123.
Bromus, a study of the leaf anatomy of some species of, 119.
- Calvin, S.**, article by, 16.
Oherokee shales, 22.
Cladocera, some Manitoba, with description of one new species, 154.
Cladocera of Iowa. Brief notes and new species of *Daphnia*, 162.
Comparative study of the leaves of *Lolium*, *Festuca* and *Bromus*, 126.
Contributions to the hemipterous fauna of Iowa, 172.
Crepidodera cucumeris, probable life history of, 170.
- Daphnia*, new species of, and brief notes on other Cladocera of Iowa, 162.
Deltocephalus, review of the genus, 195.
Drift section at Oelwein, 54.
- Eragrostis*, anatomical study of the leaves of, 138.
Evidence of a sub-Aftonian till sheet in northeastern Iowa, 50.
- Festuca*, study of the leaves of, 126.
Financial statement, 12.
Finch, Grant E., article by, 54.
Fink, B., article by, 81.
Fitzpatrick, T. J., article by, 108.
Flora of Fayette, Iowa, *Spermaphyta* of, 81.
Flora of the Sioux quartzite in Iowa, 72.
Formaldehyde, uses of in animal morphology, 147.
- Gas, natural, in the drift of Iowa, 41.**
- Hemipterous fauna of Iowa, contributions to, 172.**
Henrietta limestone, 23.
Houser, Gilbert L., articles by, 147, 151.
- Illinois Biological station, 167.
Introduced plants of Iowa, notes on, 110.
- Jassidæ, life histories of, 172**
- Keyes, C. R.**, article by, 22.
Keyes, C. R., and Rowley, R. R., article by, 26.
Leonard, A. G., article by, 41.
- Letter of transmittal, 3.
Life histories of Jassidæ, 172.
Lolium, study of leaves of, 126.
- Macbride, T. H.**, article by, 63.
Madison county, results of recent geological work in, 47.
Manitoba Cladocera, 154.
Mechanism for securing cross-fertilization in *Salvia lanceolata*, 109.
Membershio of the Academy, 7.
Memorial of Charles Wachsmuth, 13.
- Natural gas in the drift of Iowa, 41.**
New or little known plants, 108.
Nerve cells of the shark's brain, 151.
Newton, G. W., article by, 109.
Notes on aquatic plants from northern Iowa, 77.
Notes on some introduced plants of Iowa, 110.
Officers of the Academy, 5.
- Orthopterous fauna of Iowa, notes on, 234.**
Osborn, H., and Ball, E. D., article by, 172.
- Pammel, Emma**, article by, 126.
Pammel, L. H., article by, 110.
Peat bed, Pre-Kansan, 63.
Plants, new or little known, 108.
Pleasanton shales, 24.
Pre-Kansan peat bed, 63.
Probable life history of *Crepidodera cucumeris*, 170.
- Recent geological work in Madison county, results of, 47.**
Report of secretary-treasurer, 12.
Results of recent geological work in Madison county, 47.
Ross, L. S., articles by, 151, 162, 167.
Rowley, R. R., and Keyes, C. R., article by, 26.
- Salvia lanceolata*, mechanism for securing cross-fertilization in, 109.**
Secretary-treasurer, report of, 12.
Shark's brain, the nerve cells of, 151.
Shimek, B., articles by, 64, 72, 77.
Sioux quartzite in Iowa, flora of, 72.
Sirrime, Emma, article by, 119.
Sirrime, F. A., article by, 170.
some Manitoba Cladocera, with description of one new species, 154
Spermaphyta of the flora of Fayette, Iowa, 81.
Stages of the Des Moines, or chief coal-bearing series of Kansas and southwestern Missouri, and their equivalents in Iowa, 22.
State quarry limestone, 16.
Study of the leaf anatomy of some species of the genus *Bromus*, 119.
Sub-Aftonian till sheet in northeastern Iowa, evidence of, 59.
Summary of discussions, 66.
Surface deposits in Iowa, additional observations on, 68.
- Tilton, J. L.**, article by, 47.
Transmittal, letter of, 3.
- Uses of Formaldehyde in animal morphology, 147.**
- Vertical range of fossils at Louisiana, 26.**
- Wachsmuth, Charles**, memorial of, 13.
Weaver, C. B., article by, 132.











SMITHSONIAN INSTITUTION LIBRARIES



3 9088 01304 1827